The Assembly and Evolution of the Amazonian Biota and its Environment

Dimensions of Biodiversity US-BIOTA-São Paulo

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www.amazoniabiodiversity.org

FAPESP NSF NASA bioGENESIS
a core project of DIVERSITAS

Scientific challenges and goals

- How is genetic, taxonomic, and ecological diversity distributed within Amazonia?
- What has been the evolutionary history of the Amazonian biota and how was it generated?
- What has been the history of the Amazonian aquatic and terrestrial environments?
- How has the Amazonian environment and its biota evolved together, and what have been the global effects of this evolutionary-ecological system over time?

Requires a new integrated approach

NSF-NASA-FAPESP project: broad-scale collaboration

Brazil

- Universidade de São Paulo
- Universidade Federal de Goiás
- Universidade Federal do Pará
- Universidade Estadual de Campinas
- Museu Paraense Emílio Goeldi
- Instituto Nacional de Pesquisas da Amazônia

Argentina

- CONICET-Instituto Superior de Entomologia, Tucumán

Great Britain

- University of Edinburgh

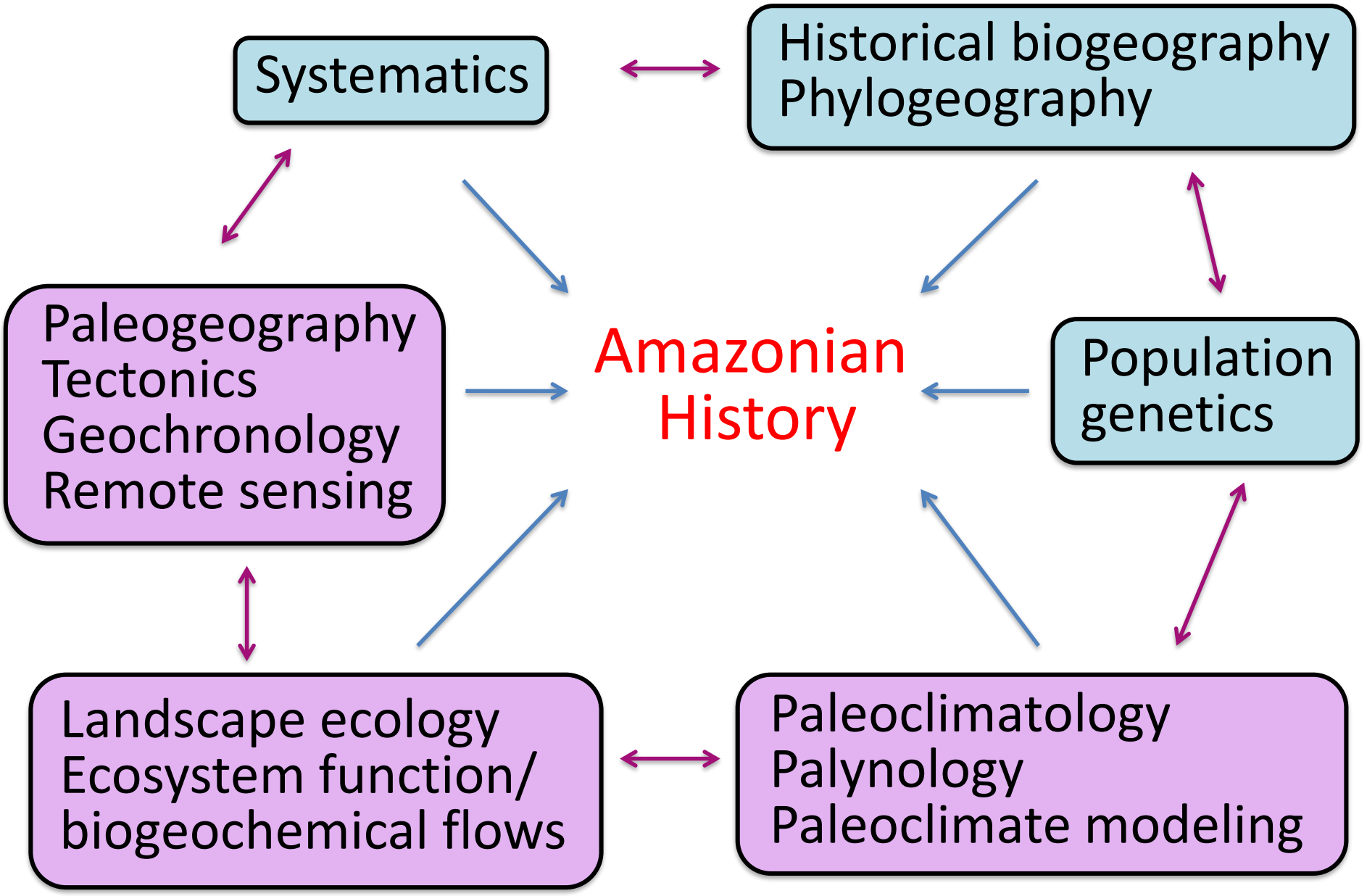
Canada

- University of Toronto

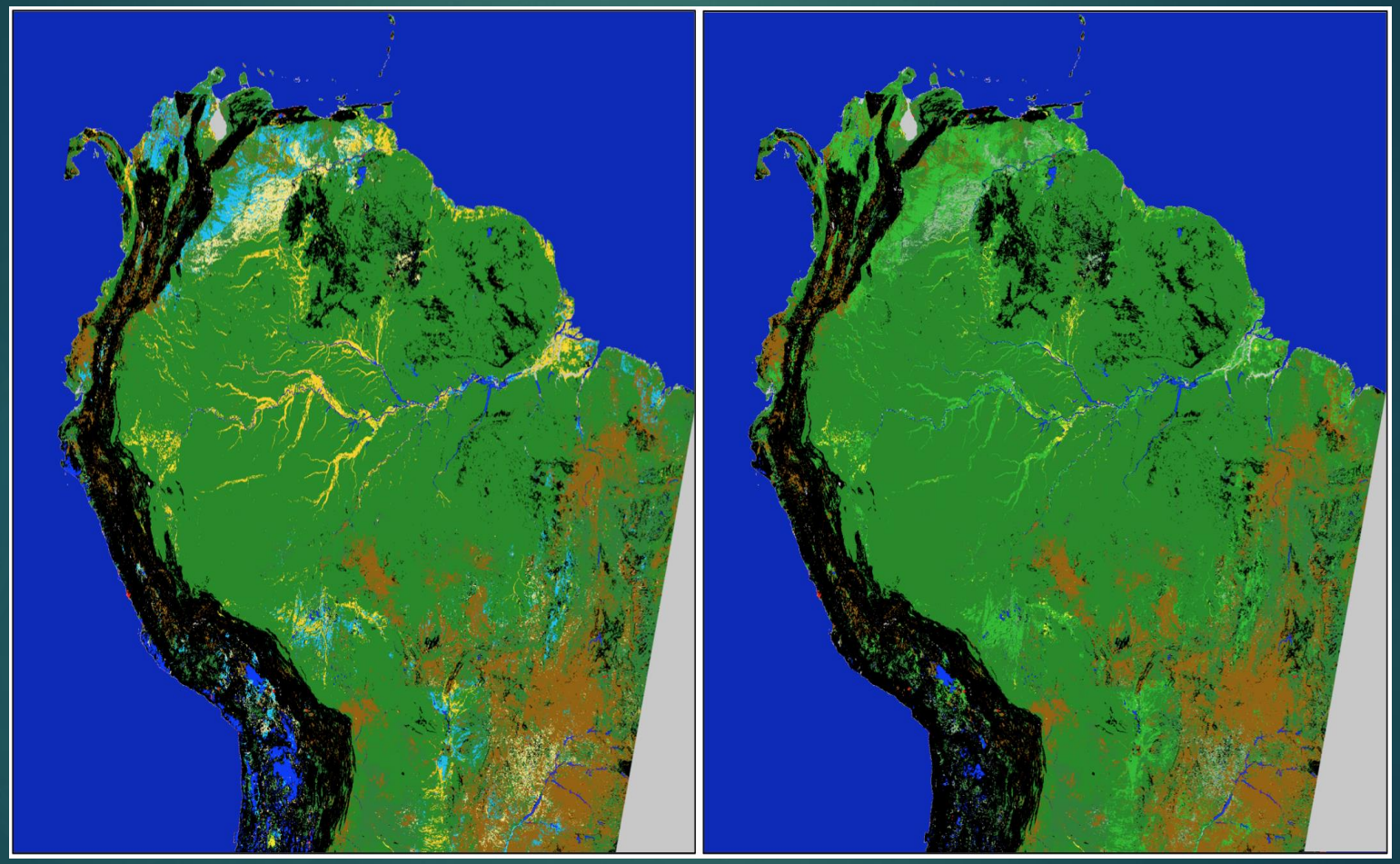
United States

- American Museum of Natural History
- City University New York
- Field Museum of Natural History
- Middle Tennessee State University
- Natural History Museum Los Angeles County
- New York Botanical Garden
- University of Michigan
- University of Colorado

Integration across disciplines



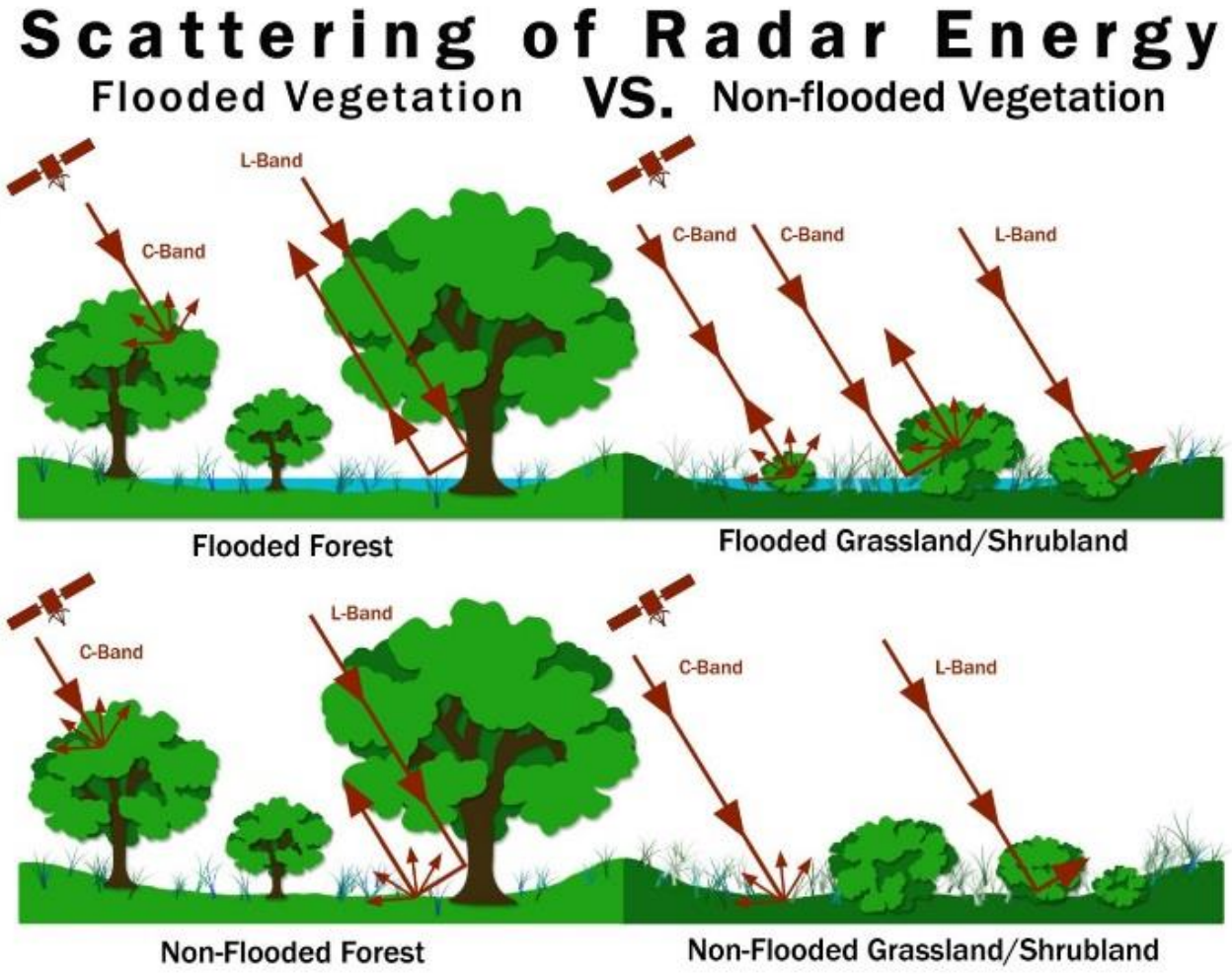
Seasonal Maximum/Minimum Inundation from ALOS PALSAR ScanSAR



Chapman et al, 2015

Synthetic Aperture Radar (SAR)

- Sensor spectral **frequency** determines the surface and volume scattering contributions from the vegetation canopy and the ability to detect standing water at the surface



C-band:

~6cm, 4-8GHz

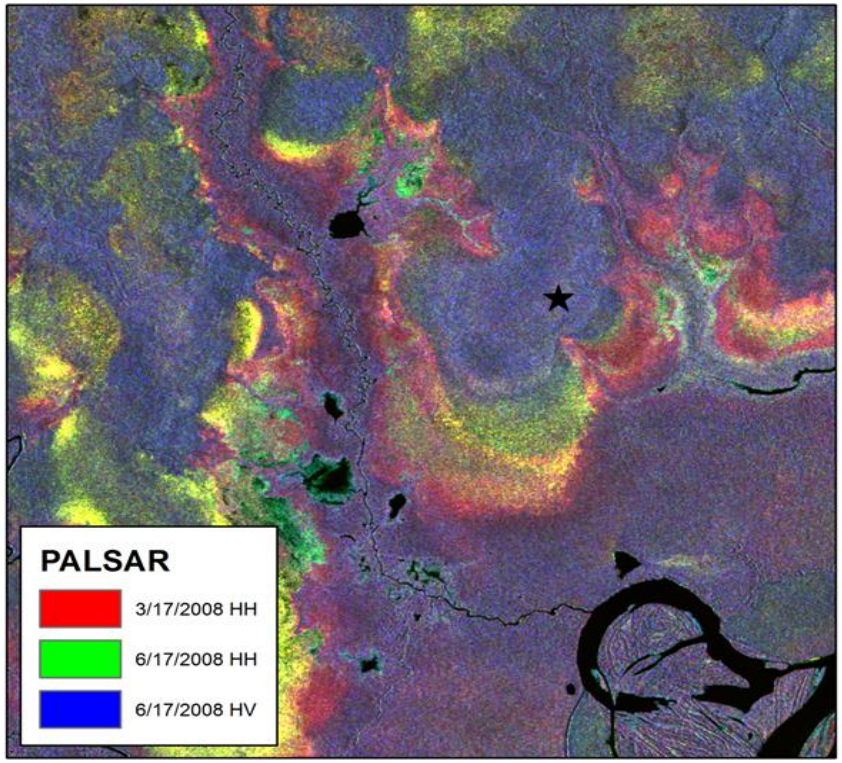
L-band:

~23cm, 1-2GHz

Bourgeau-Chavez *et al*., 2016

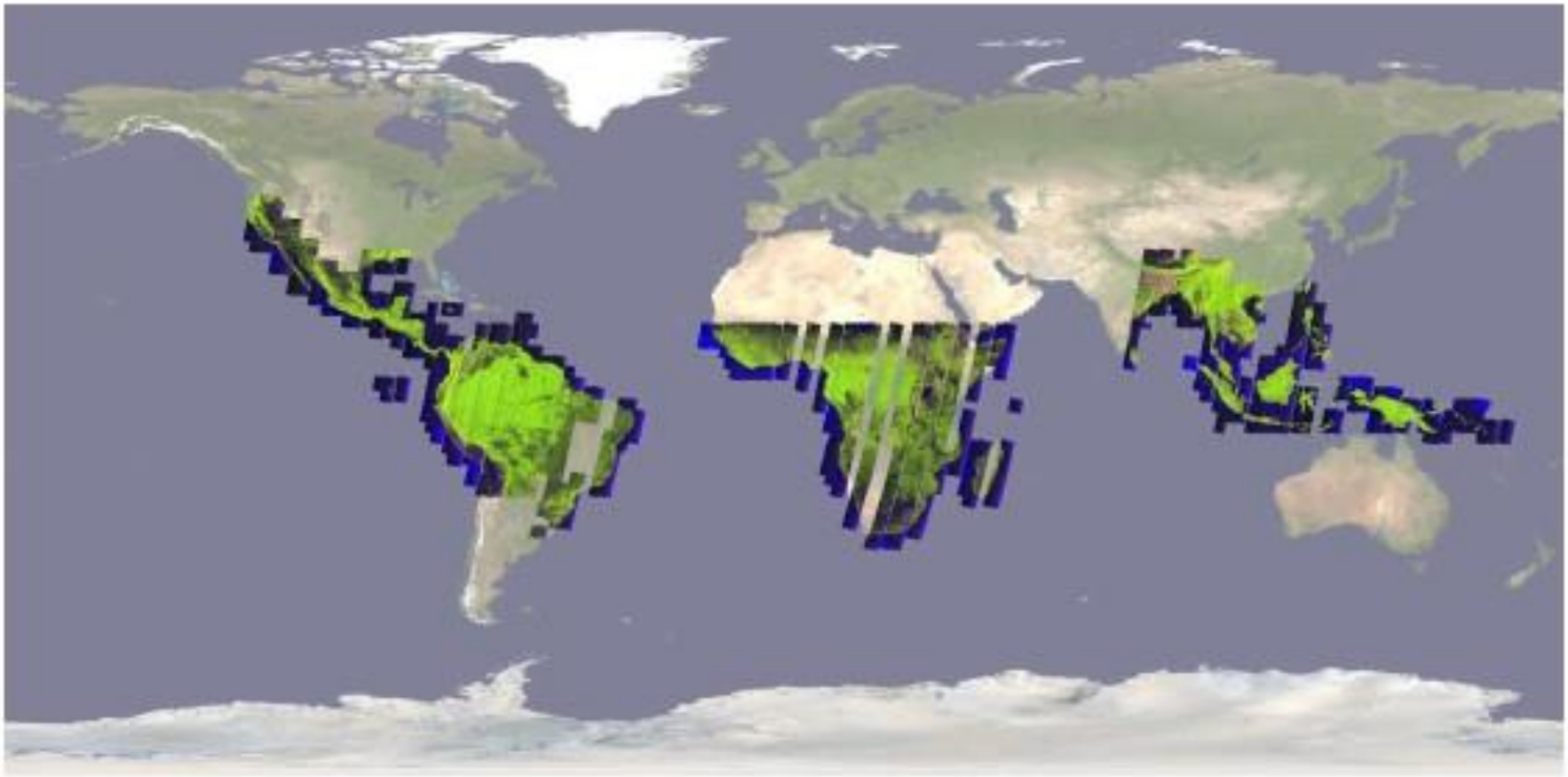
Synthetic Aperture Radar (SAR)

- The different interactions of microwave data (PALSAR) with surface water compared to vegetation enable improved discrimination of inundated areas
- Comparing images from multiple dates (multi-temporal) improves understanding of hydrology and helps to distinguish wetlands and wetland types



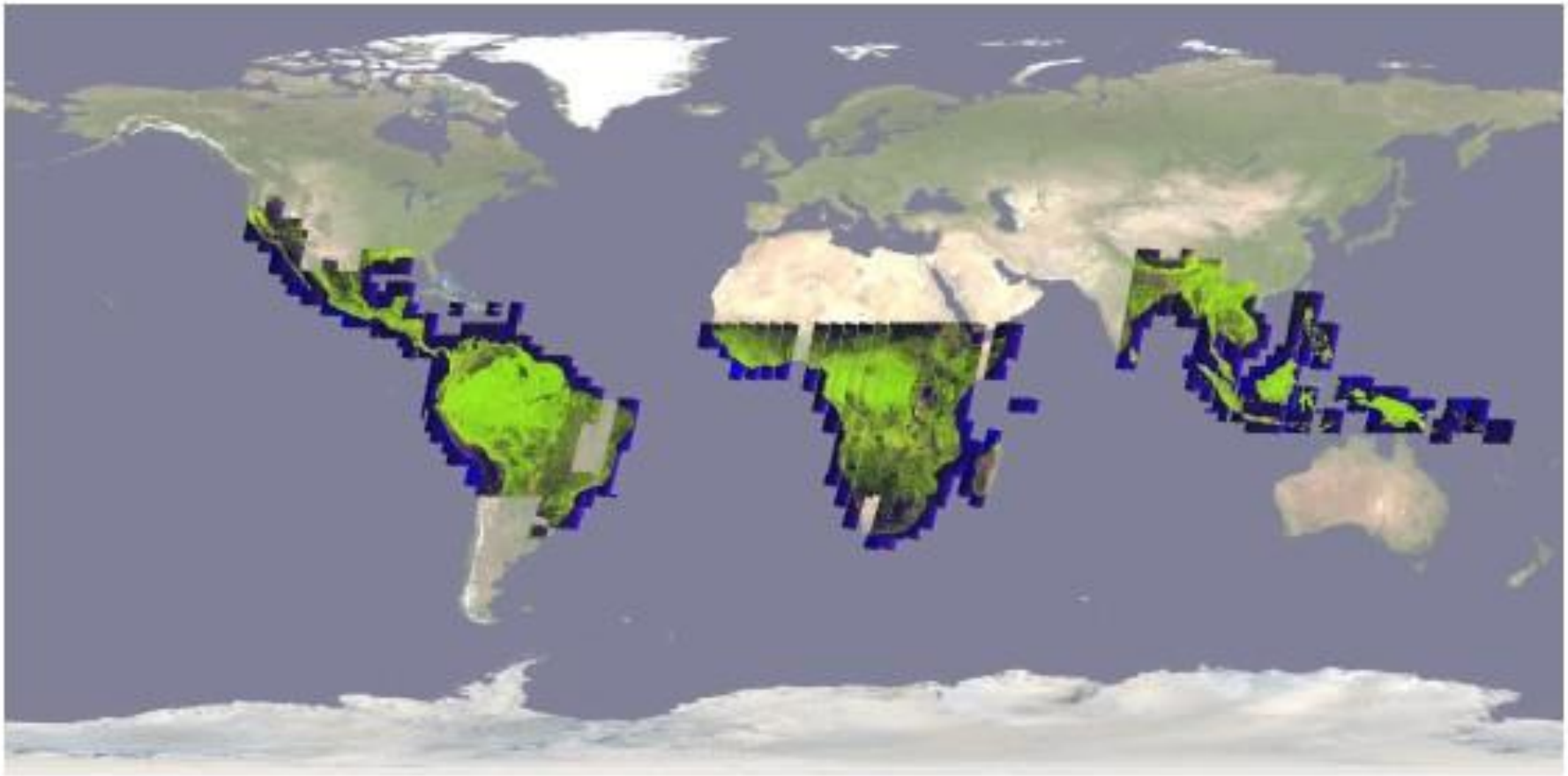
- False color composite of multi-temporal and multi-polarized observations from ALOS PALSAR of a region of the Peruvian Amazon Basin near the Marañón River.
- Color variation is mostly driven by differences in hydrologic condition. The areas in brighter colors are sloping portions of a peat dome

PALSAR 2 ScanSAR Coverage



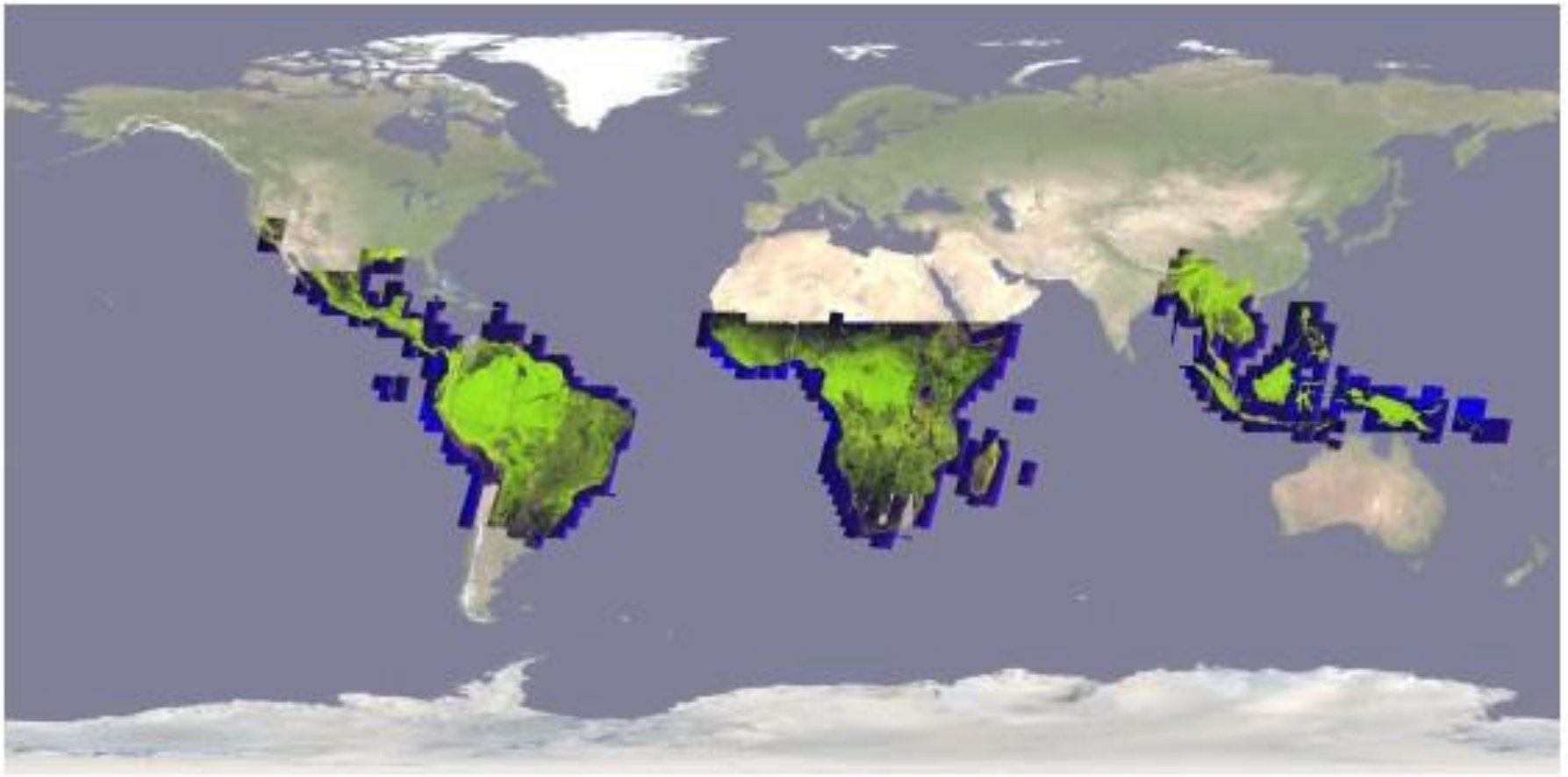
Cycle_085	9-Oct-17 - 22-Oct-17

PALSAR 2 ScanSAR Coverage



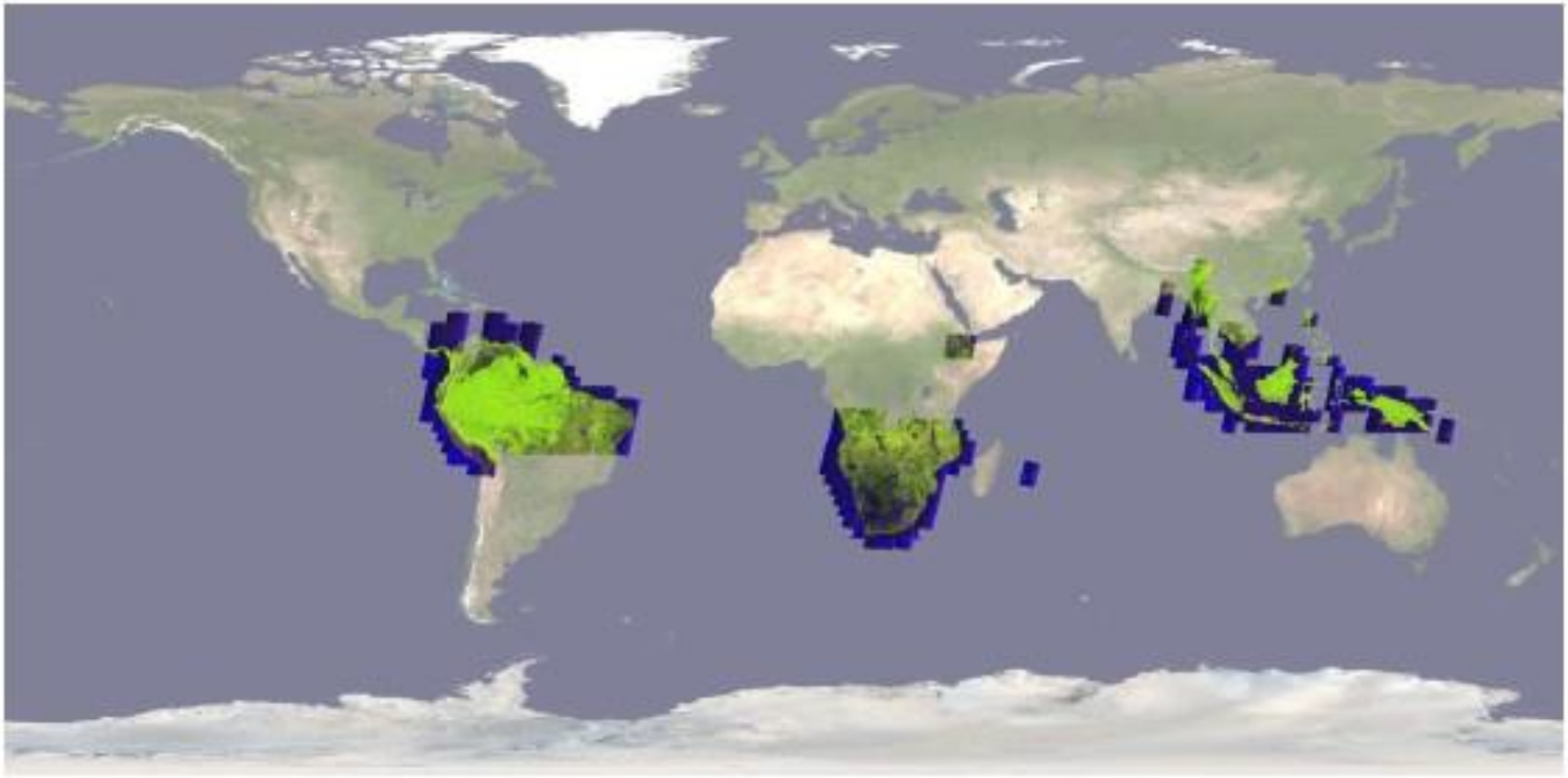
Cycle_088	20-Nov-17 - 3-Dec-17

PALSAR 2 ScanSAR Coverage



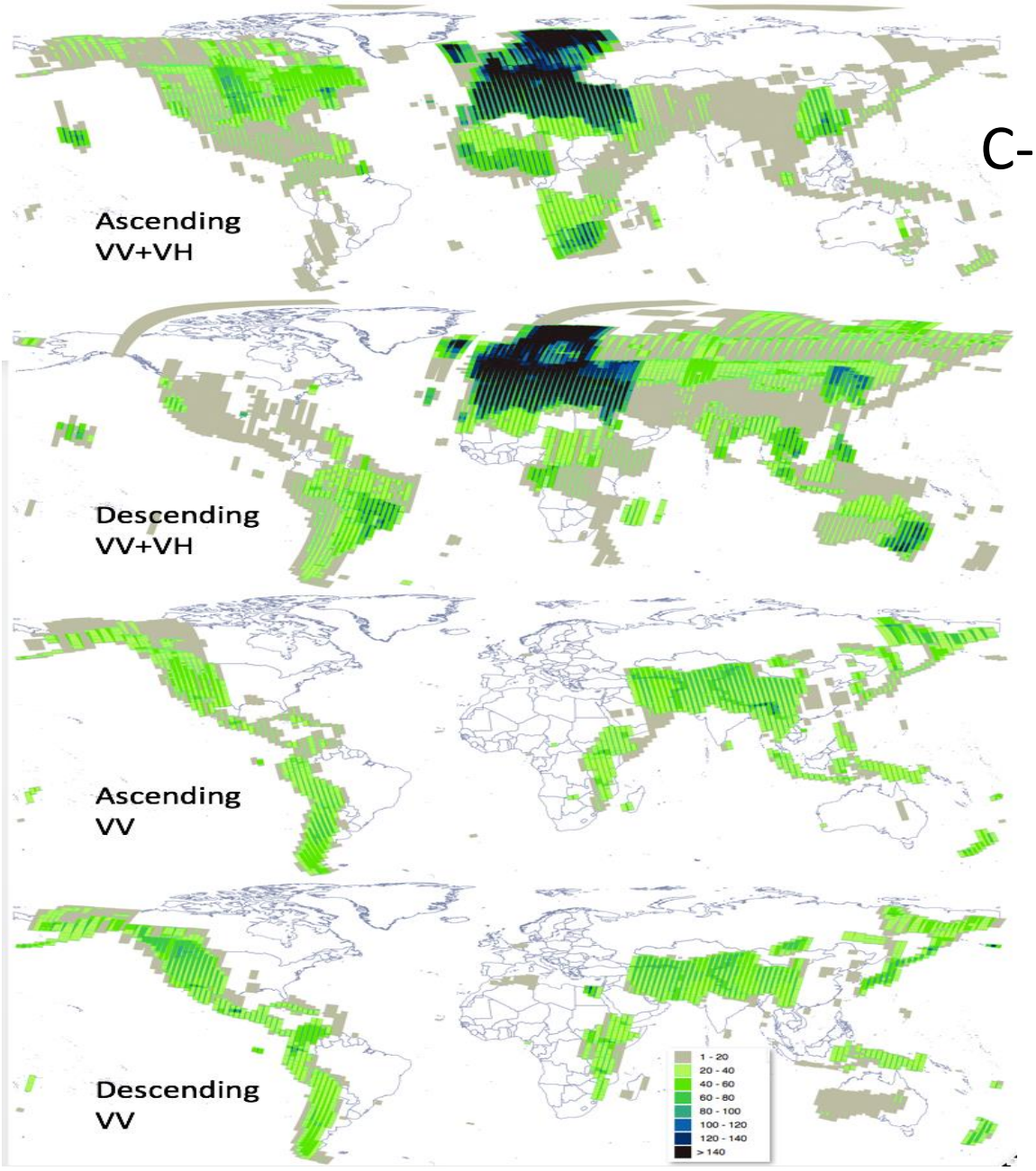
Cycle_091	1-Jan-18 - 14-Jan-18

PALSAR 2 ScanSAR Coverage



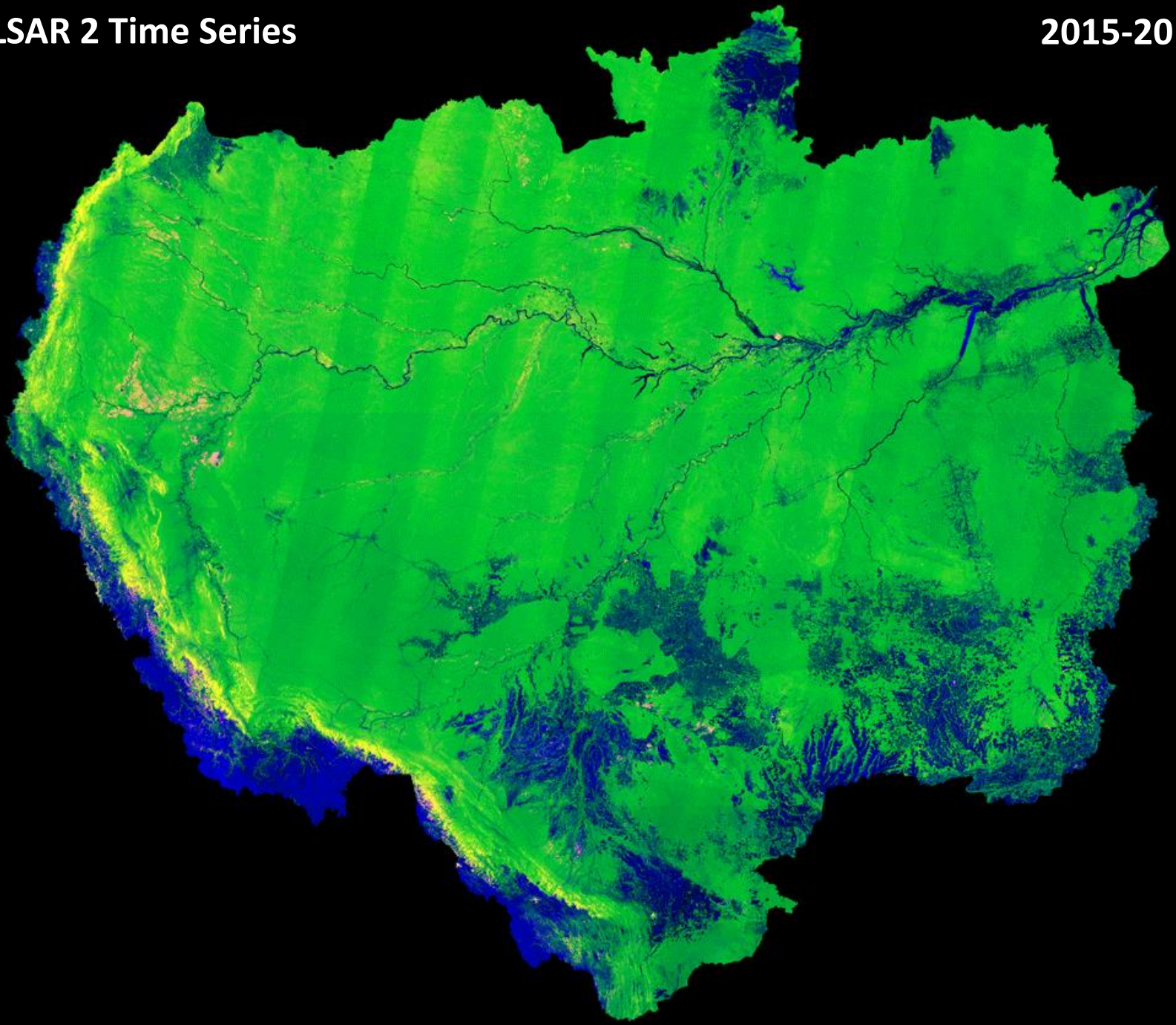
Cycle_093	29-Jan-18 - 11-Feb-18

Sentinel-1 A/B
C-band SAR coverage



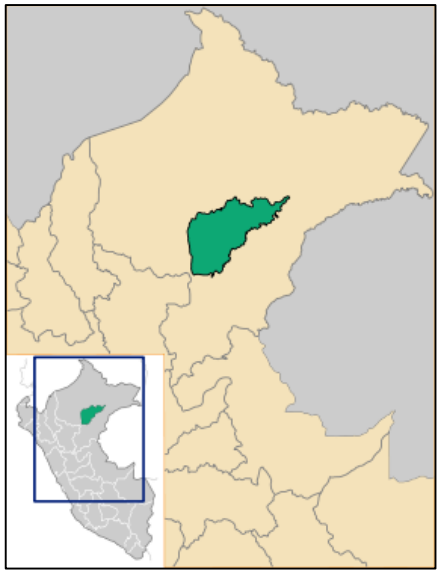
PALSAR 2 Time Series

2015-2017



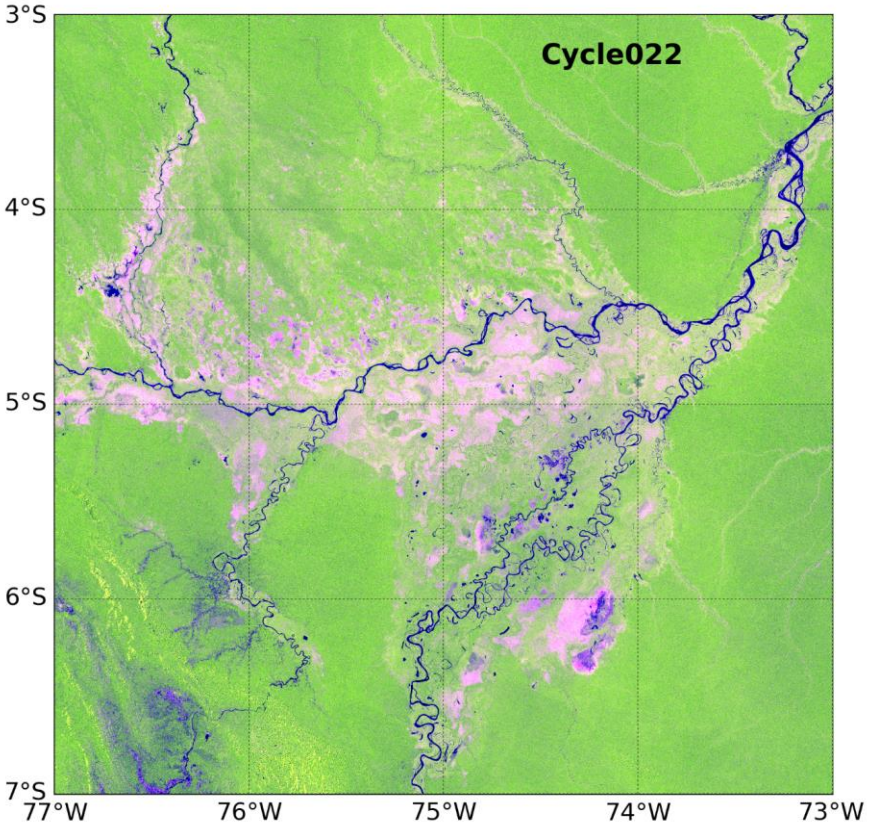
Pacaya-Samiria National Reserve, Peru

- Most extensive tropical flooded forest in the Peruvian Amazon
- Spans area of more than 20,000 km²
- Hosts rich biodiversity
- Home to variety of wetland types, primarily palm swamp

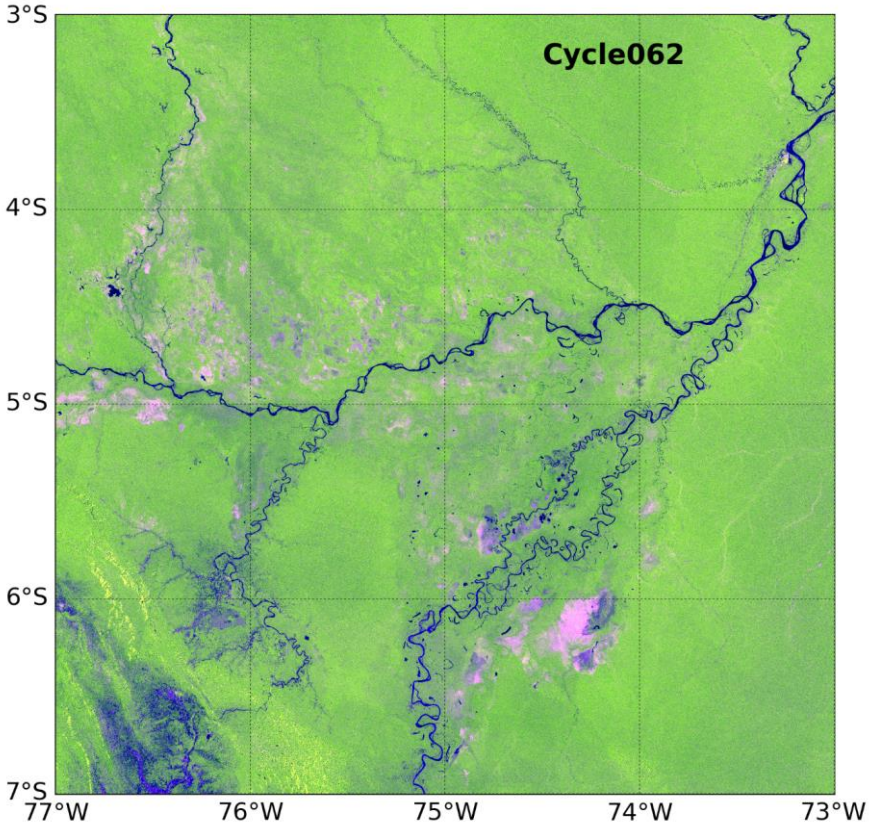


ALOS2 PALSAR-2 Dual Pol ScanSAR Mosaics **R**: HH, **G**: HV, **B**: HH-HV

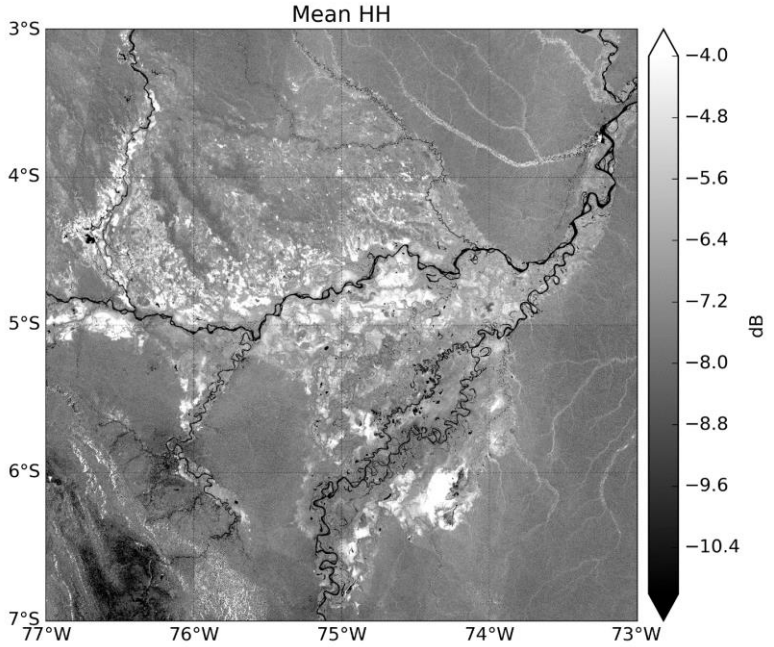
End of Wet Season - May 2015

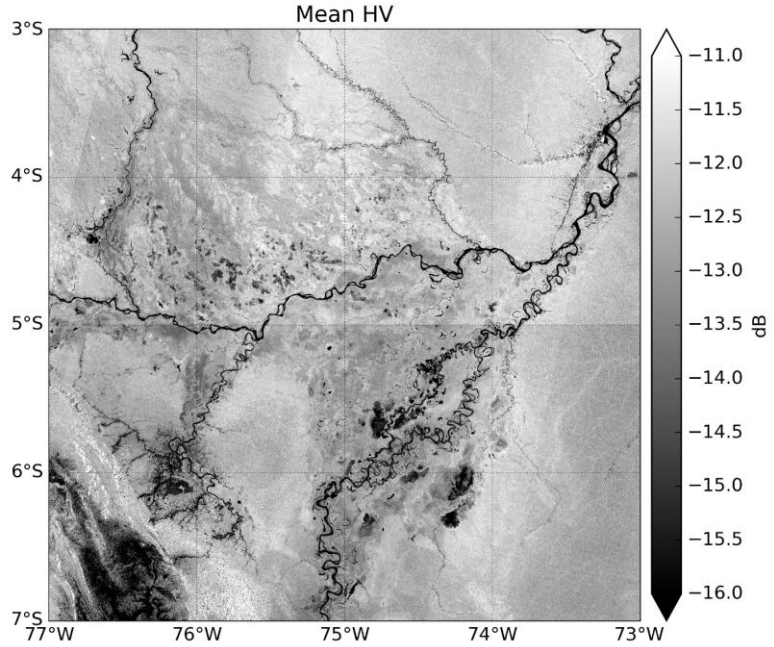


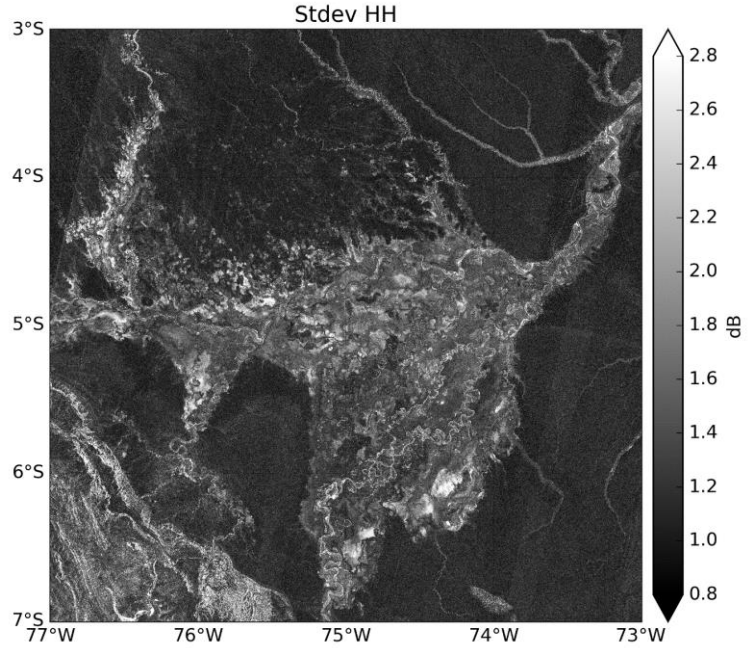
End of Dry Season – Nov 2015

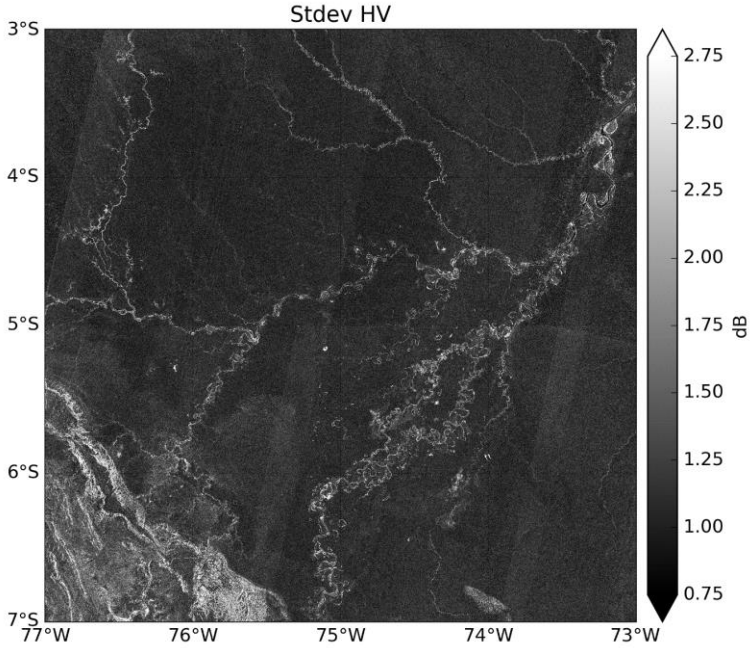


Multi-temporal Statistics from 20 ALOS-2 ScanSAR ensembels (Nov 2014 – Feb 2017)



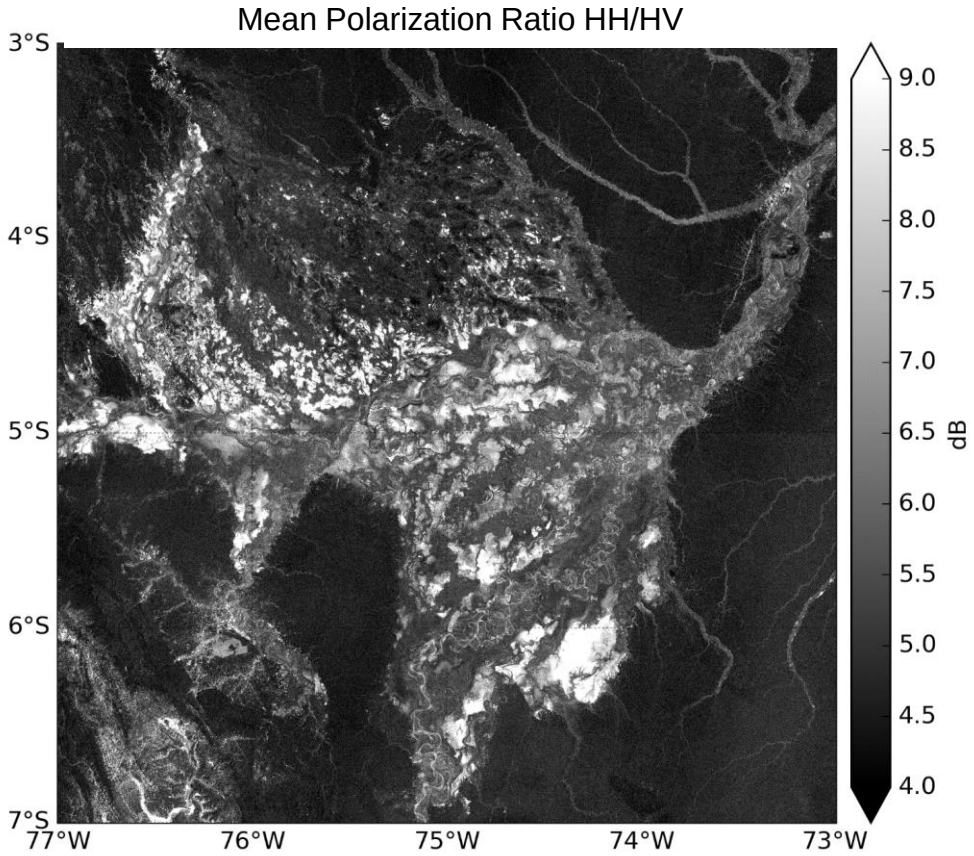






Multi-temporal Statistics

- Calculated from 20 ALOS-2 ScanSAR scenes (Cycles #010 – #068; Nov 2014 – Feb 2017)



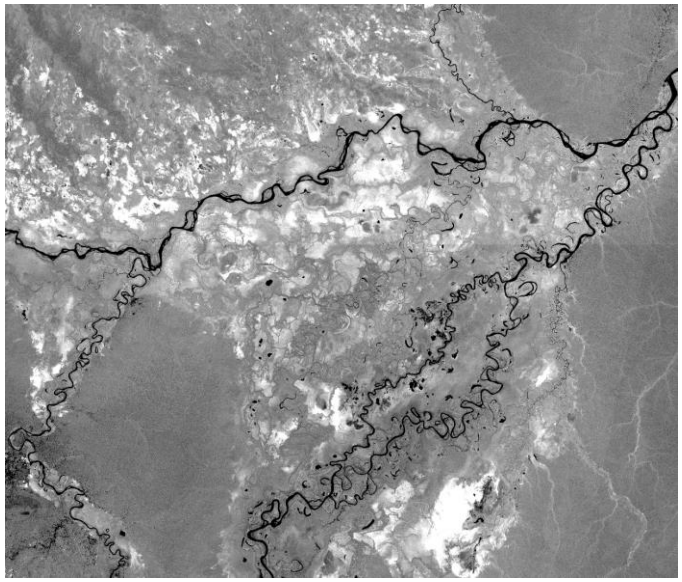
HH more sensitive to seasonal changes inundated vegetation

HV useful in discriminating vegetation structure - seasonally flooded low vegetation (grasses, etc)

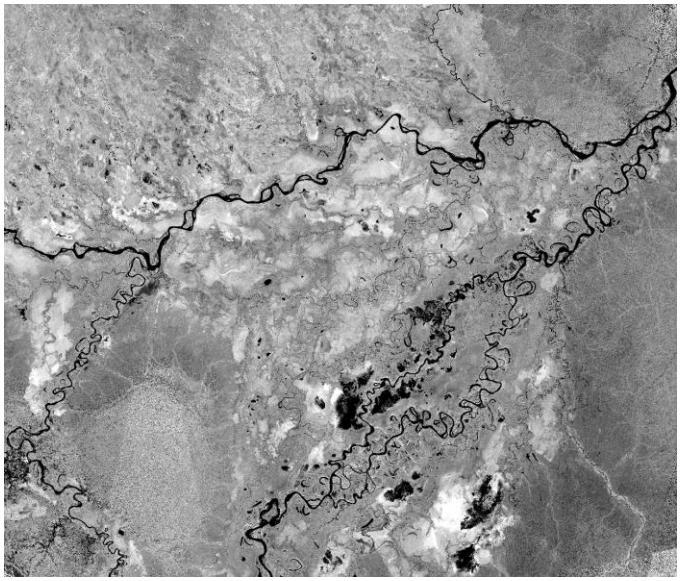
Polarization Ratio (HH/HV) potentially helpful at discriminating flooded vs. non-flooded vegetation

Multi-temporal Statistics, calculated from observations made in Jan 2015 – Dec 2017

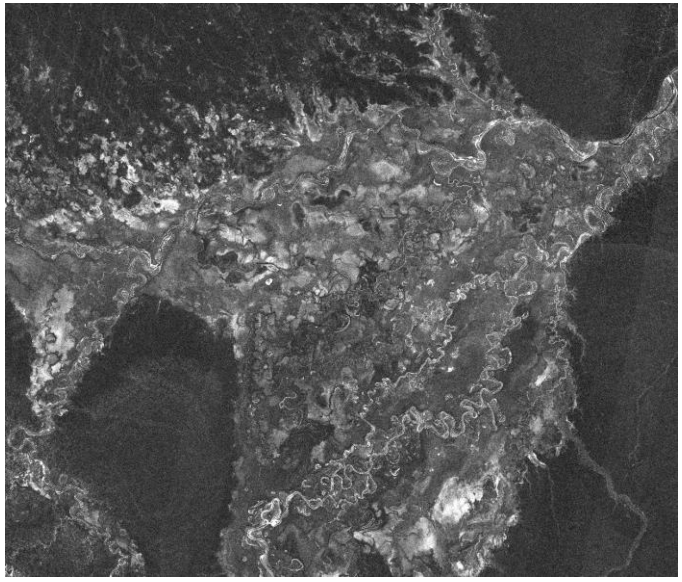
HH Mean [PALSAR-2, L-band]



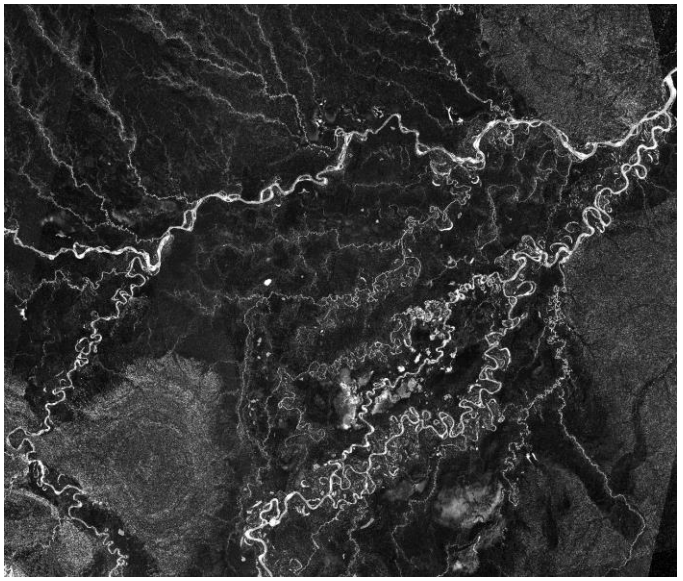
VV Mean [Sentinel-1, C-band]



HH Stdev [PALSAR-2, L-band]

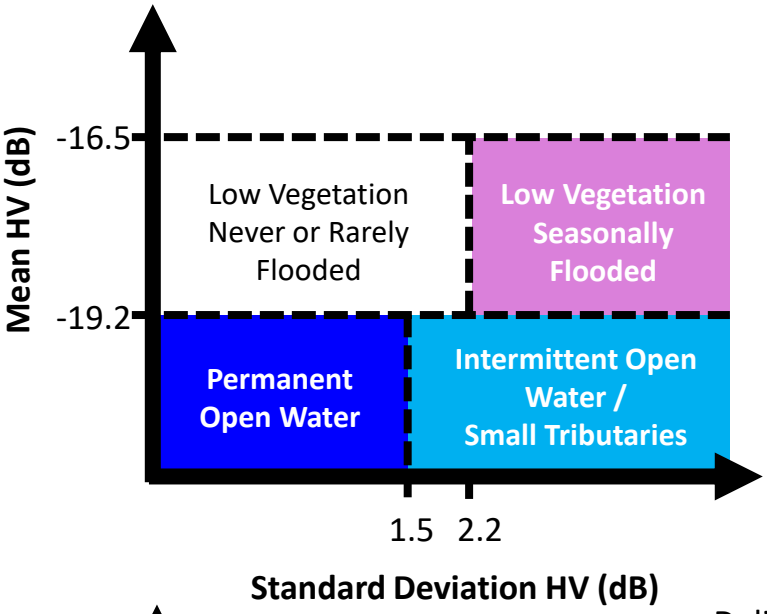


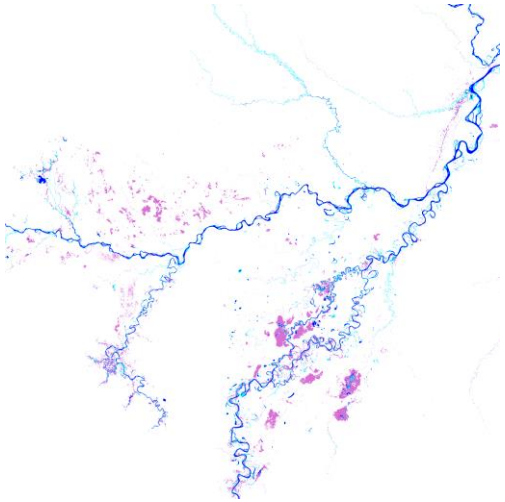
VV Stdev [Sentinel-1, C-band]



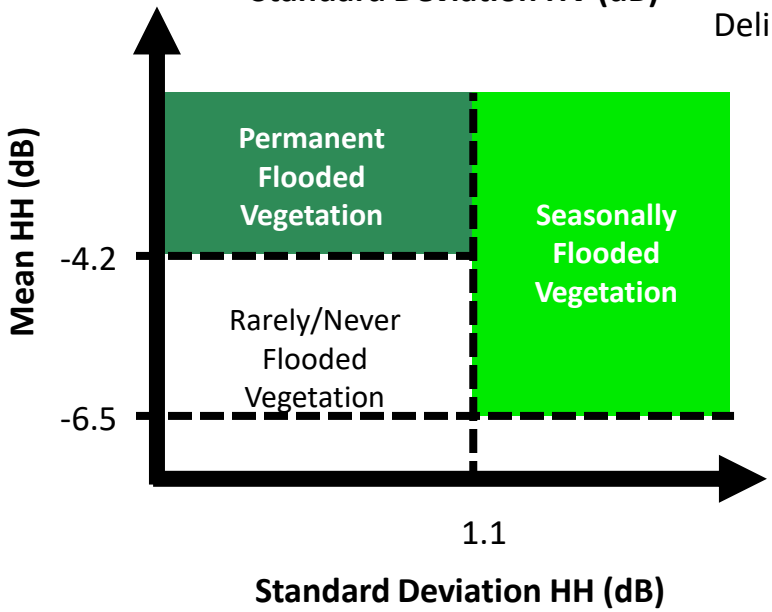
Classification: Pacaya Samiria

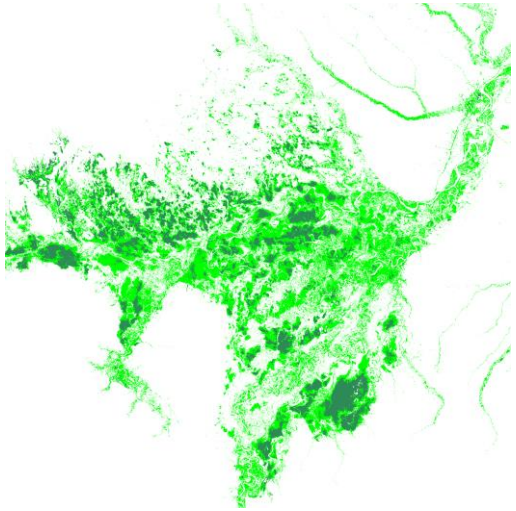
Delineating Open Water + Flooded Low Vegetation (Permanent & Seasonal)





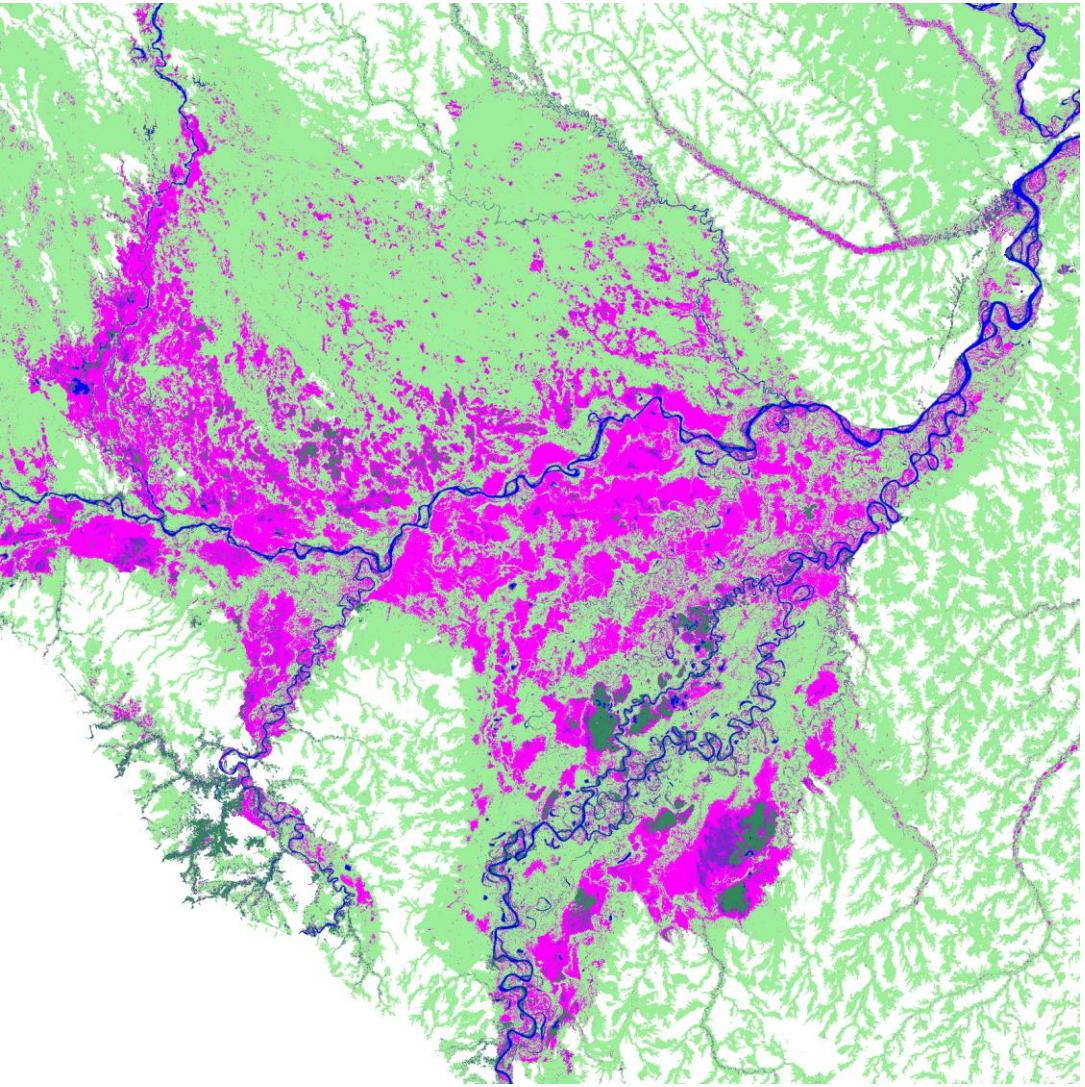
Delineating Inundated Vegetation (Permanent & Seasonal)





** Elevation > 150m masked out*

Land Cover Classification Based on Multi-temporal PALSAR 2
Pacaya Samiria National Reserve, Peru



Permanent Open Water

Intermittent Open Water / Flooded Low Vegetation

Seasonally Flooded Forest

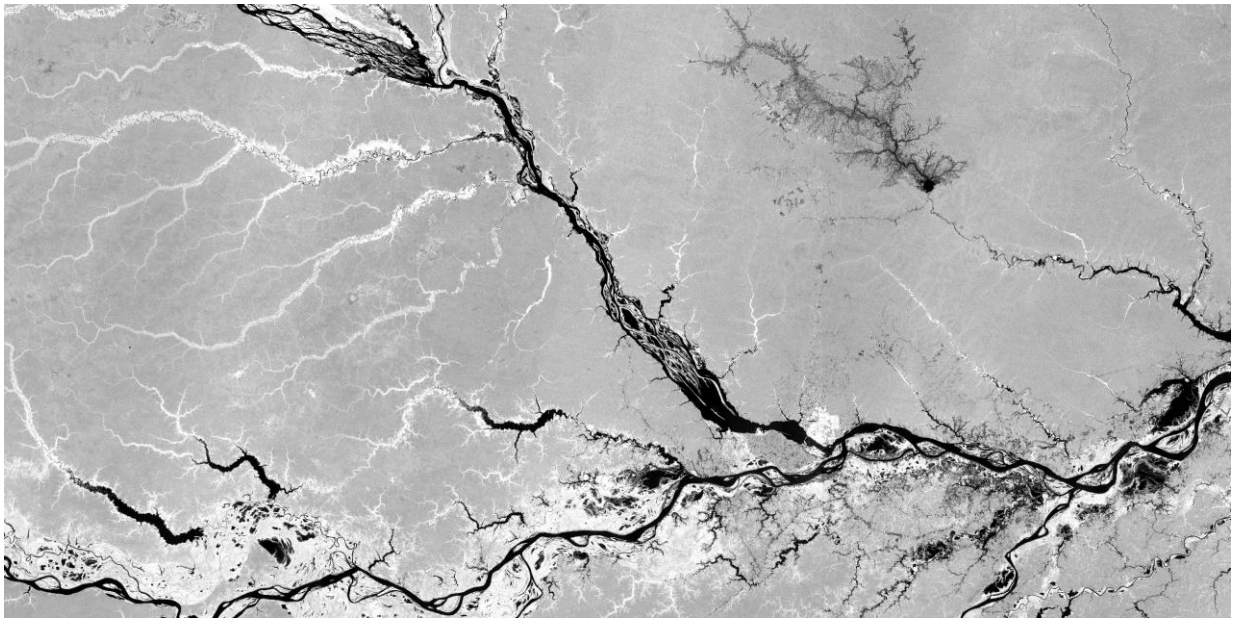
Permanent Flooded Forest

Never Flooded

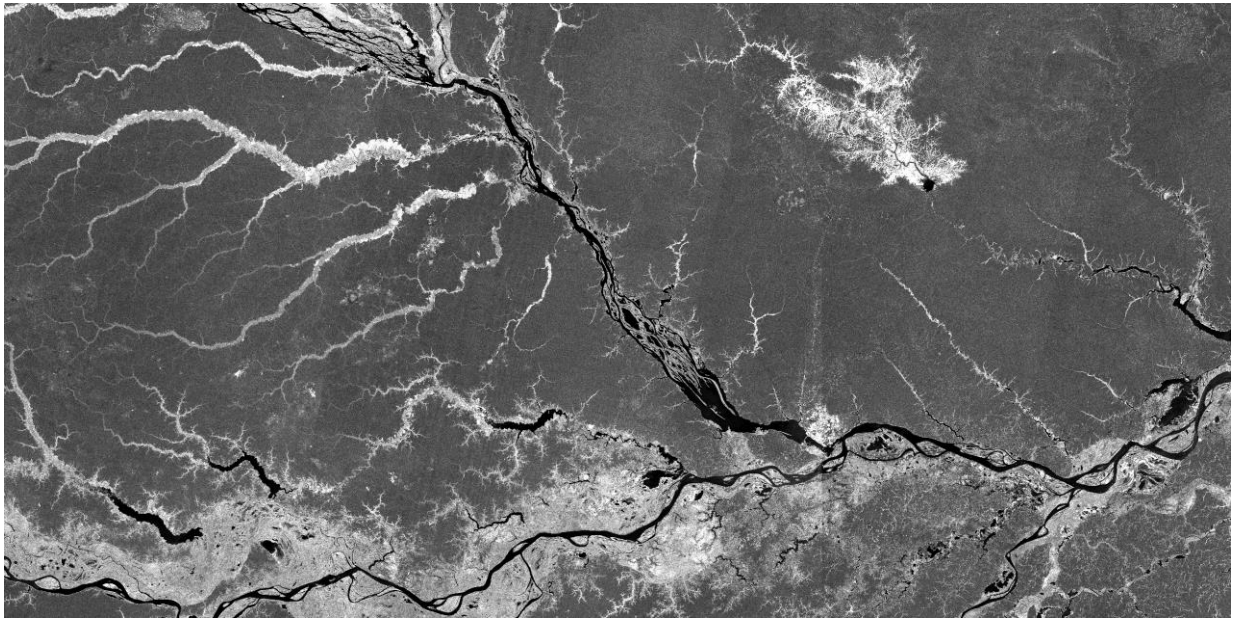
Regions where Height Above Nearest Drainage (HAND) index > 20m masked out in white

PALSAR Backscatter Statistics

Central Amazon

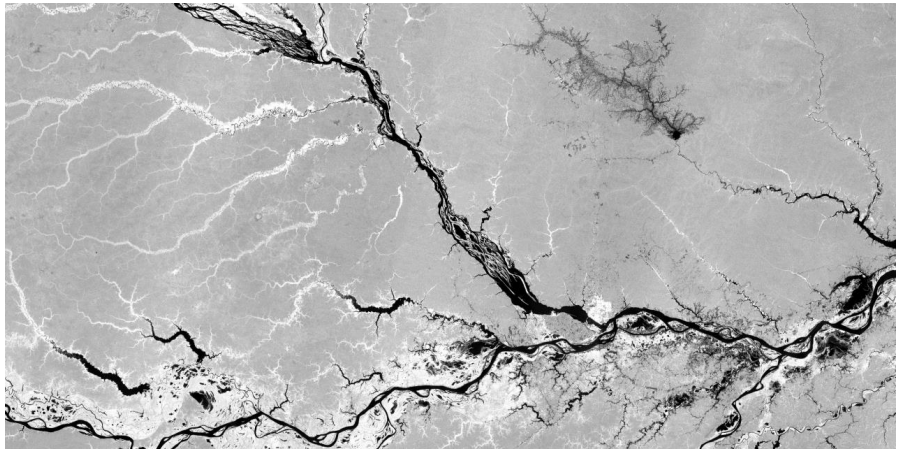


HH Mean

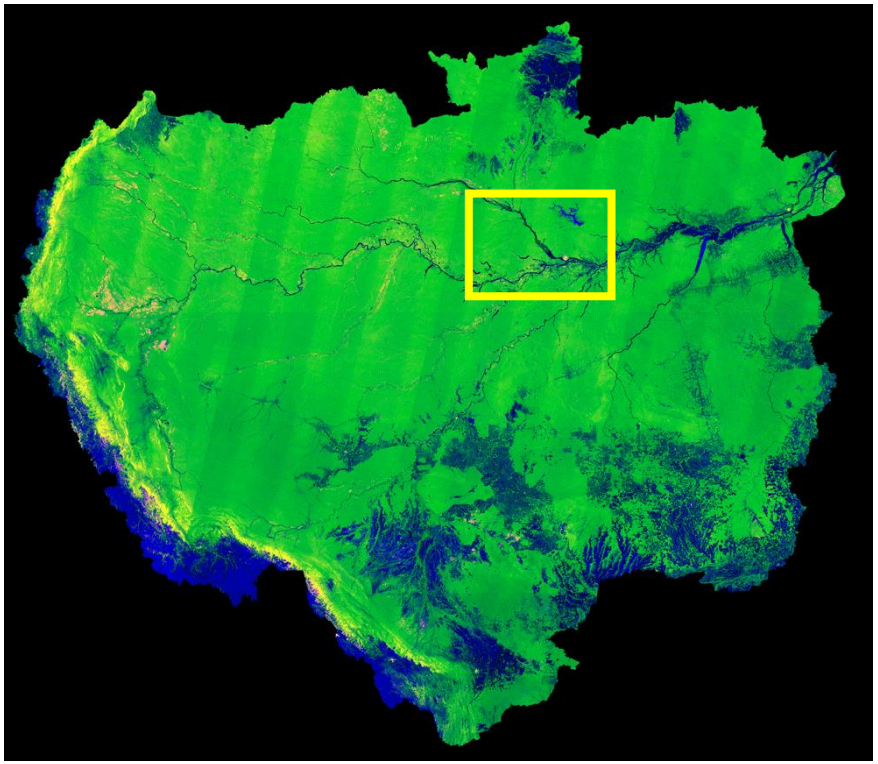


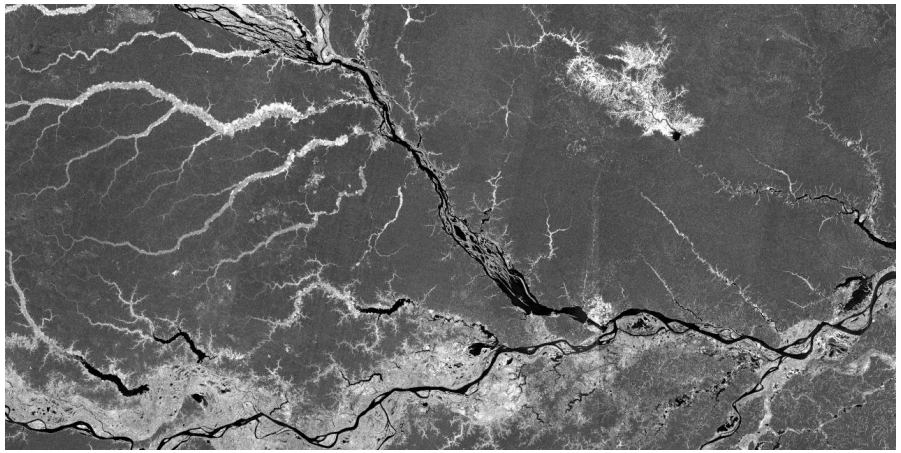
HH St Dev

PALSAR Backscatter Statistics: Central Amazon

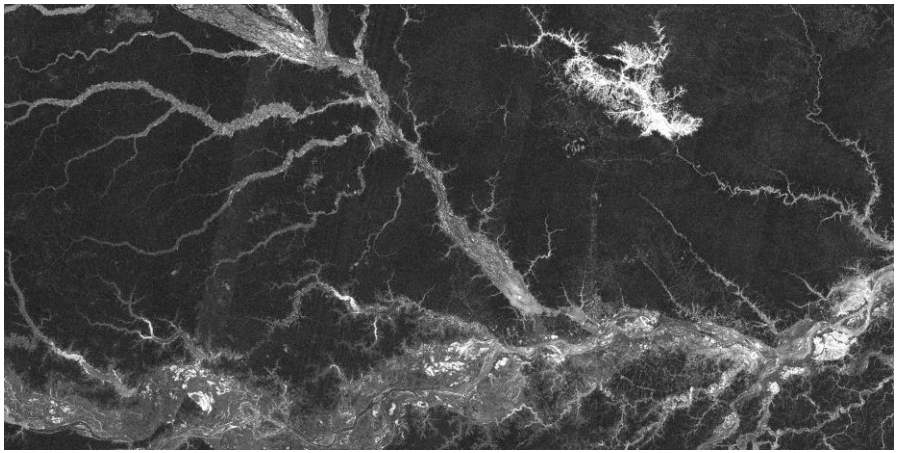


HH Mean





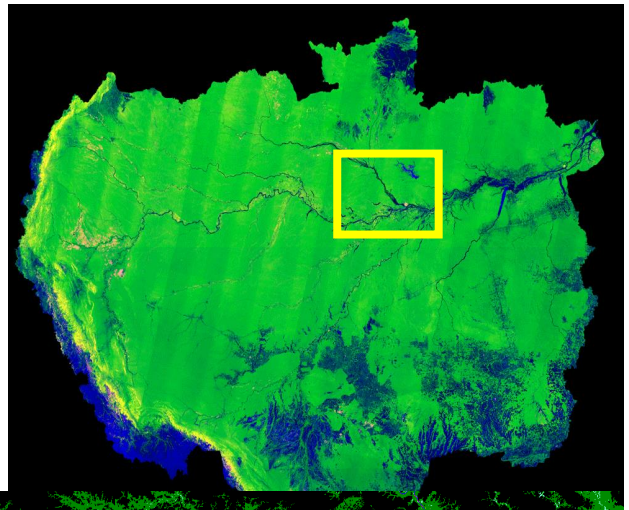
HH St Dev

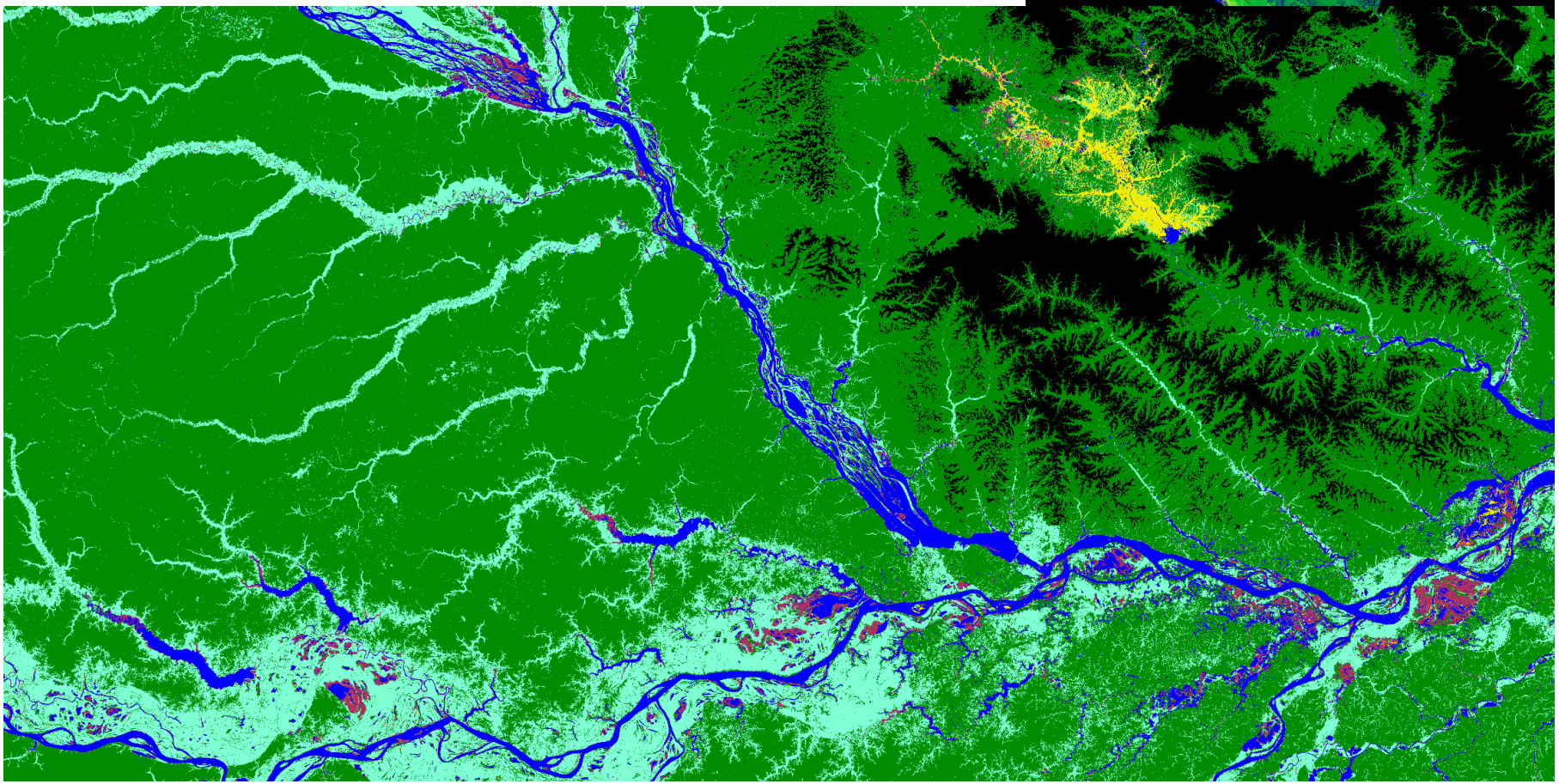


HH Max – Min:
Dynamic Range in dB

Dark Blue: Open water
Light Blue: Inundated Forest
Green: Never Flooded Forest/Vegetation
Yellow: Balbina Dam region
Maroon: Seasonally submerged forest
Black: Masked areas

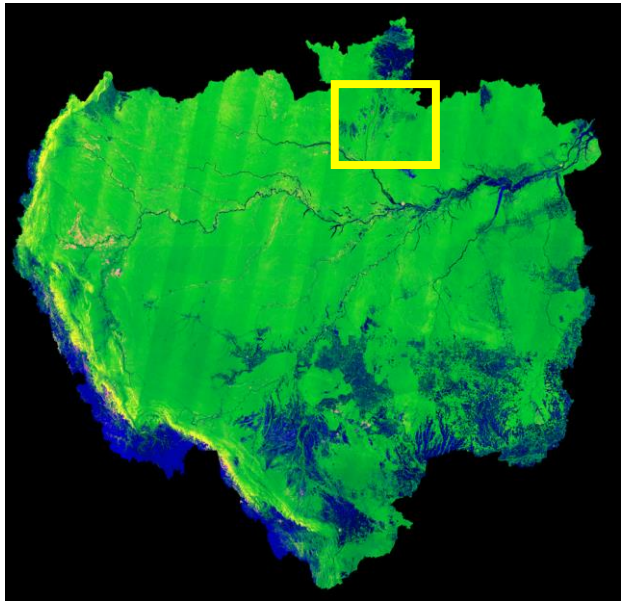
PALSAR Classification: Central Amazon

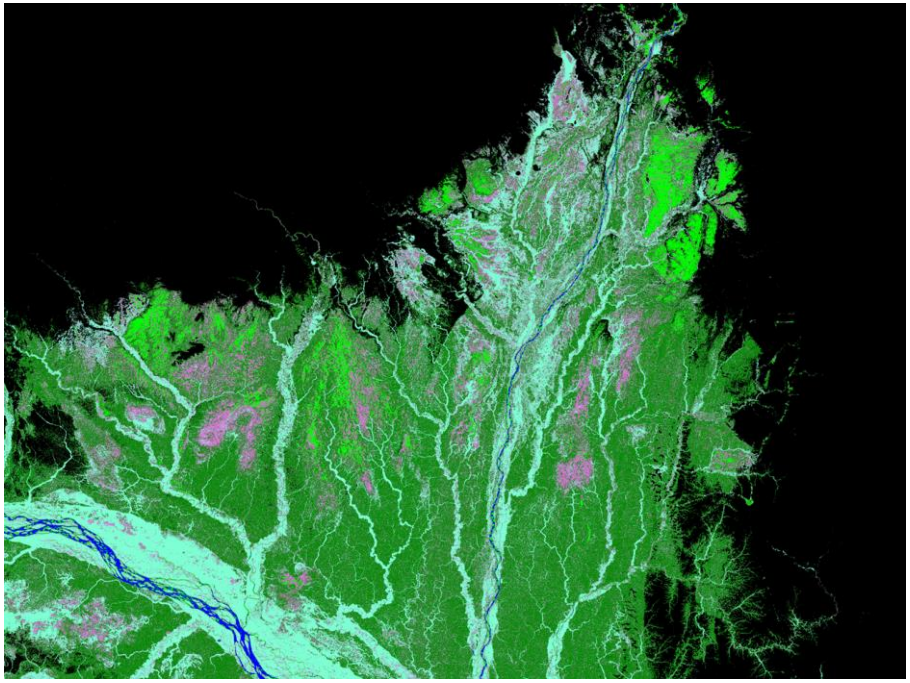


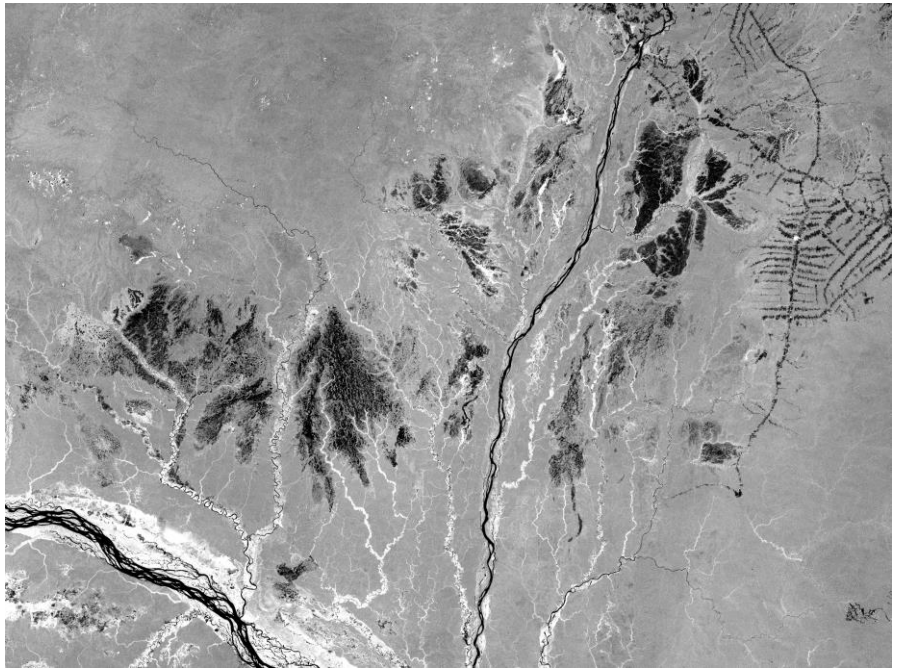


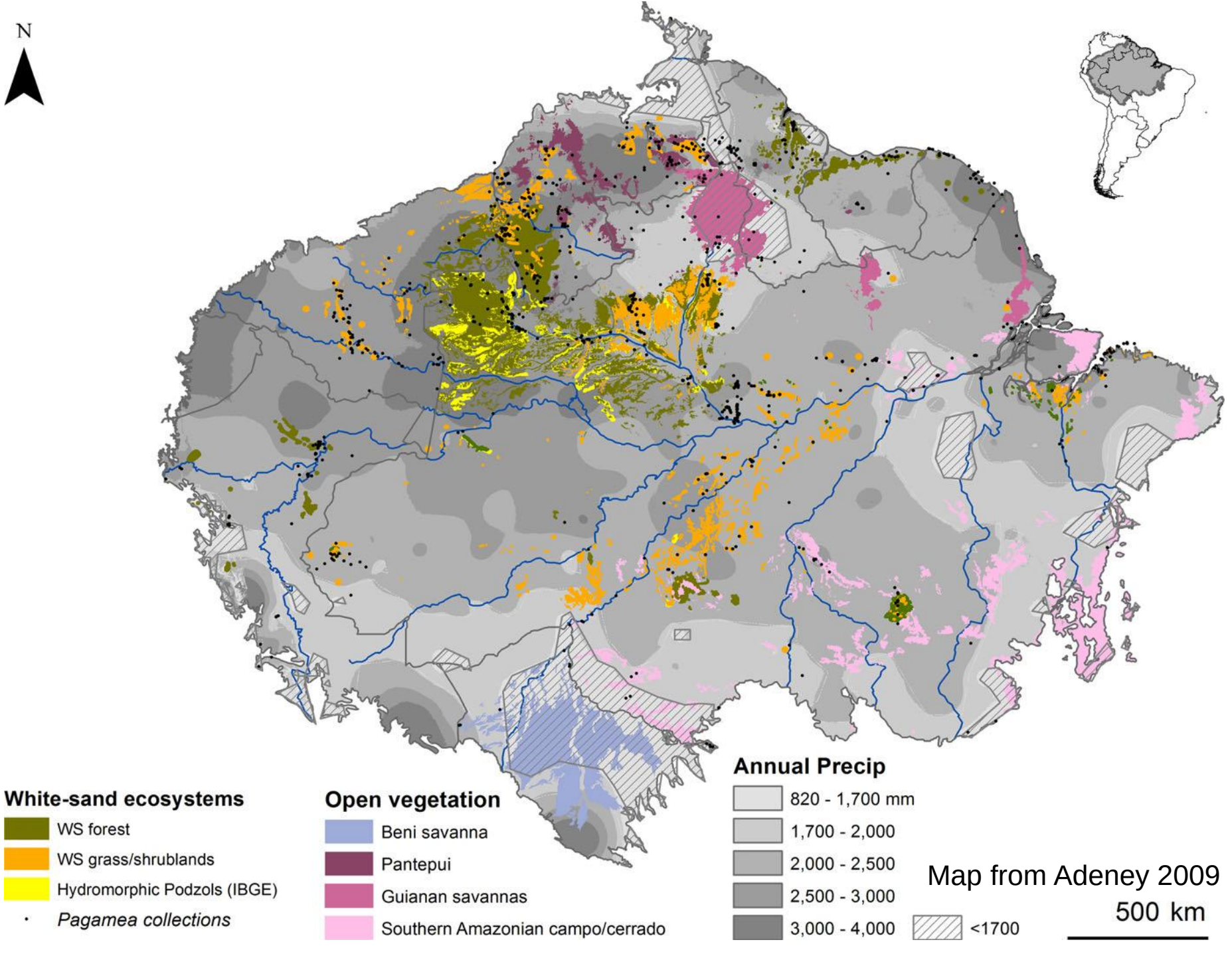
PALSAR Classification: Rio Branco Region

Dark Blue: Open water
Light Blue: Inundated Forest
Green: Never Flooded Forest/Vegetation
Yellow: Balbina Dam region
Maroon: Seasonally submerged forest
Black: Masked areas



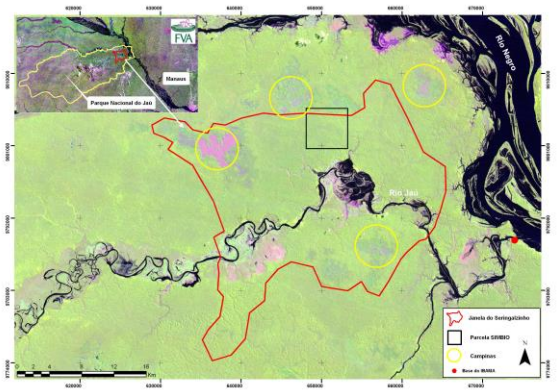


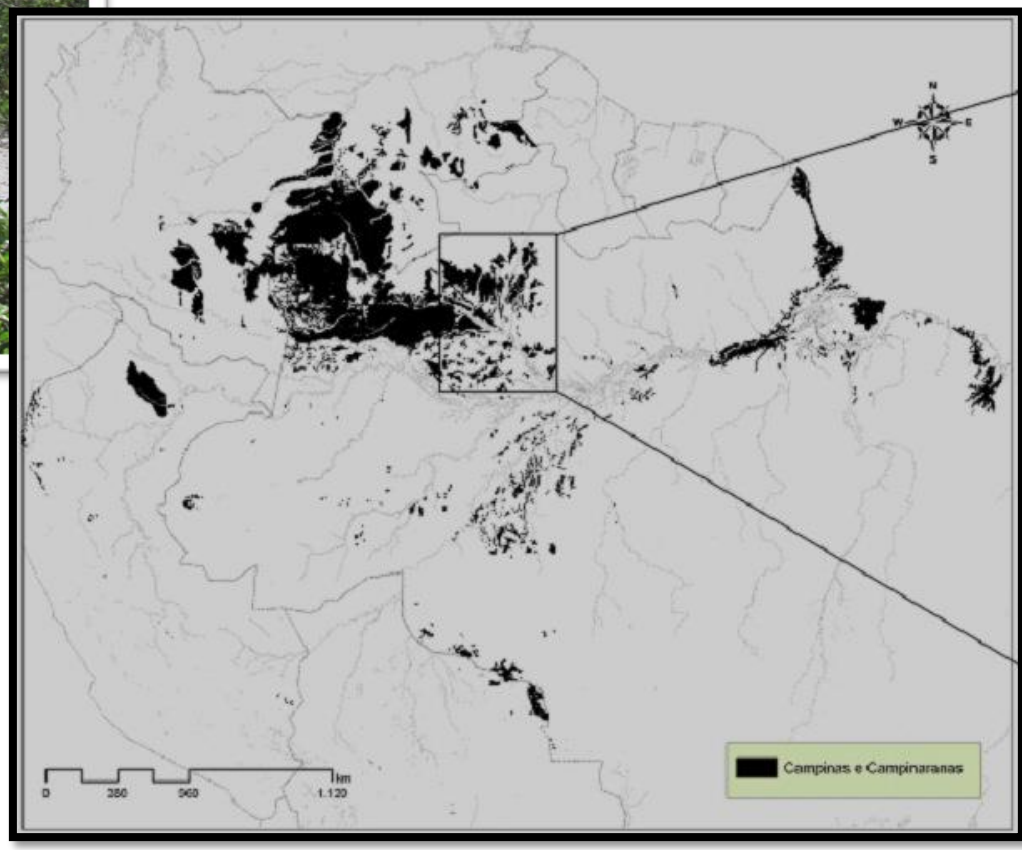



N
White-sand ecosystems
WS forest
WS grass/shrublands
Hydromorphic Podzols (IBGE)
Pagamea collections
Open vegetation
Beni savanna
Pantepui
Guianan savannas
Southern Amazonian campo/cerrado
Annual Precip
820 - 1,700 mm
1,700 - 2,000
2,000 - 2,500
2,500 - 3,000
3,000 - 4,000
<1700
Map from Adeney 2009
500 km

White-sand avifauna

What can we learn about Amazonia landscape history?





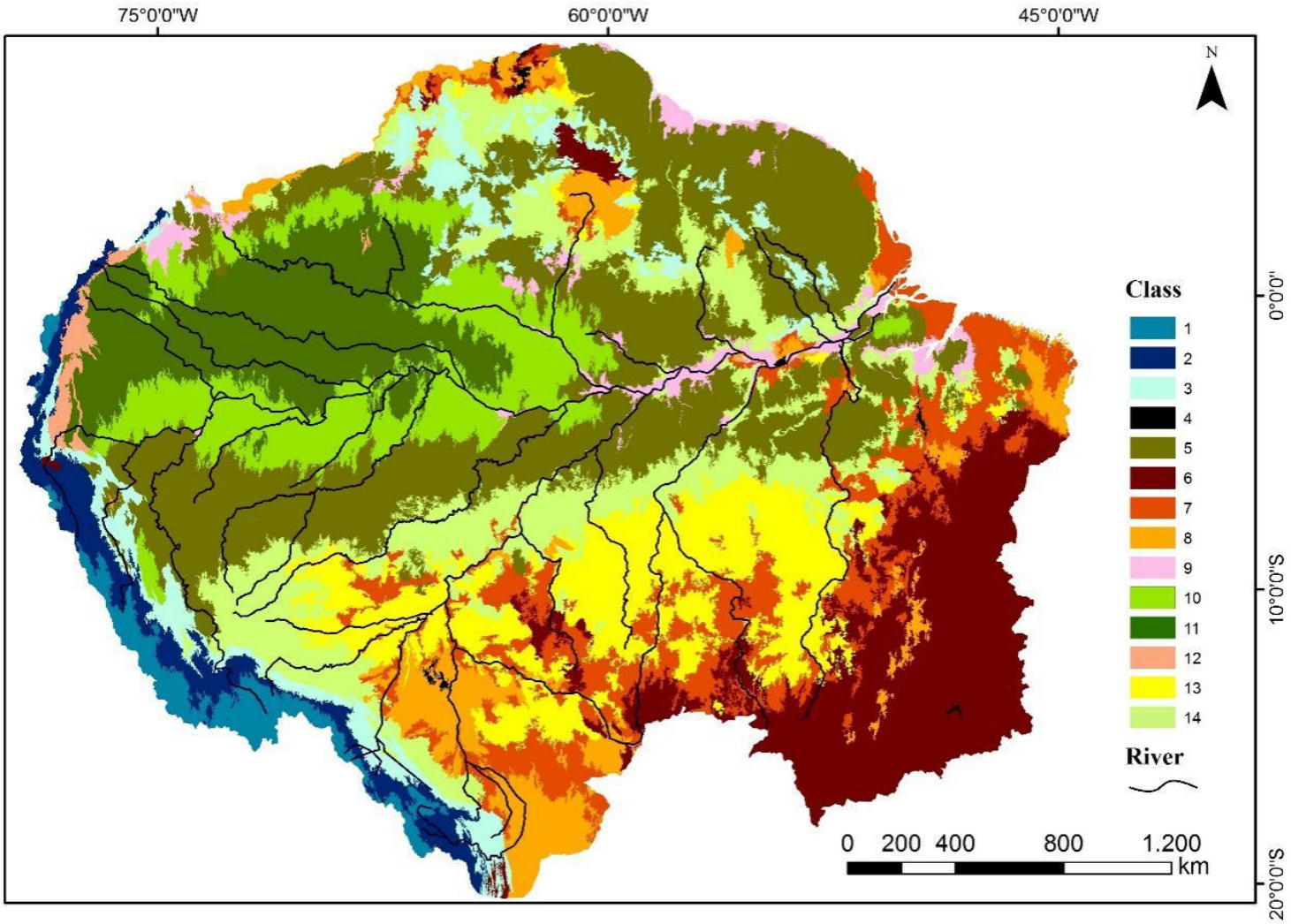
Map from Vicentini 2007

Bioclimatic Envelopes

Source, layer of representation environmental (Layer), spatial resolution (Resolution) and attribute type (Attribute) used to map bioclimatic envelopes to Amazon Basin.

Source	Layer	Resolution	Attribute
SRTM (Shuttle Radar Topography Mission)	Elevation	90 m	Abiotic
SRTM (Shuttle Radar Topography Mission)	Slope	90 m	Abiotic
SRTM (Shuttle Radar Topography Mission)	Aspect	90 m	Abiotic
CHIRPS (Climate Hazards group InfraRed Precipitation with Station data)	Maximum precipitation	5,5 km	Abiotic
CHIRPS (Climate Hazards group InfraRed Precipitation with Station data)	Minimum precipitation	5,5 km	Abiotic
PALSAR (Phased Array type L band Synthetic Aperture Radar)	HH polarization	100 m	Abiotic/Biotic
MODIS (Moderate Resolution Imaging Spectroradiometer)	NDVI	250 m	Biotic
Avitabile et al., 2016	Canopy height	1km	Biotic
MODIS (Moderate Resolution Imaging Spectroradiometer)	Isothermality	1km	Abiotic

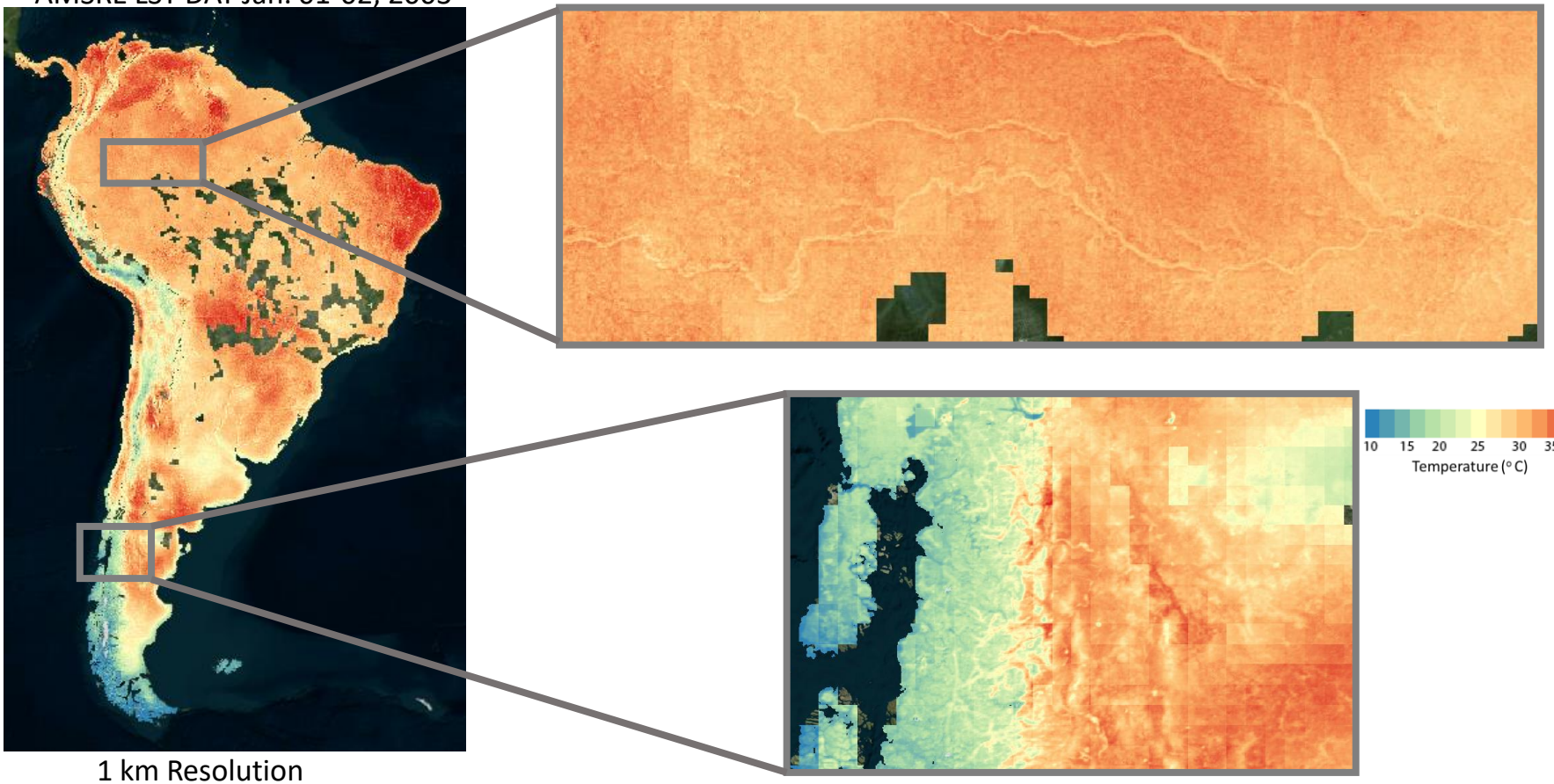
Bioclimatic Envelopes



Final map of the distribution from bioclimatic envelopes in the Amazon basin with 14 classes.

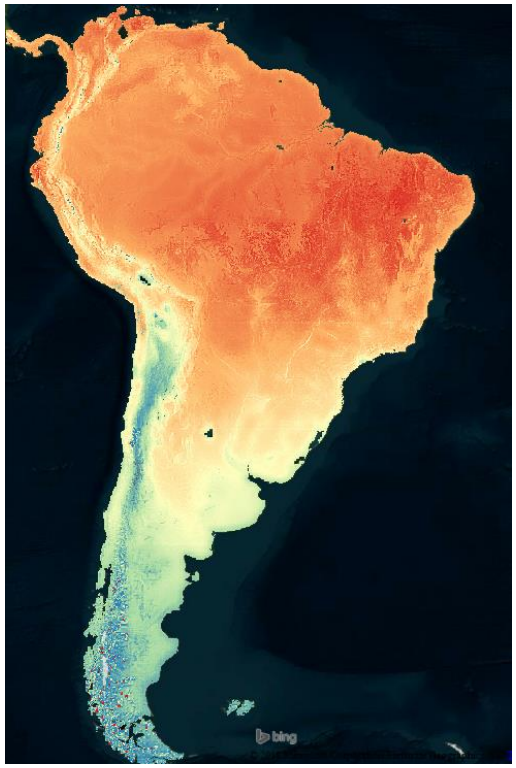
Downscaled 1km AMSRE Land Surface Temperature

AMSRE LST DAY Jan. 01-02, 2003

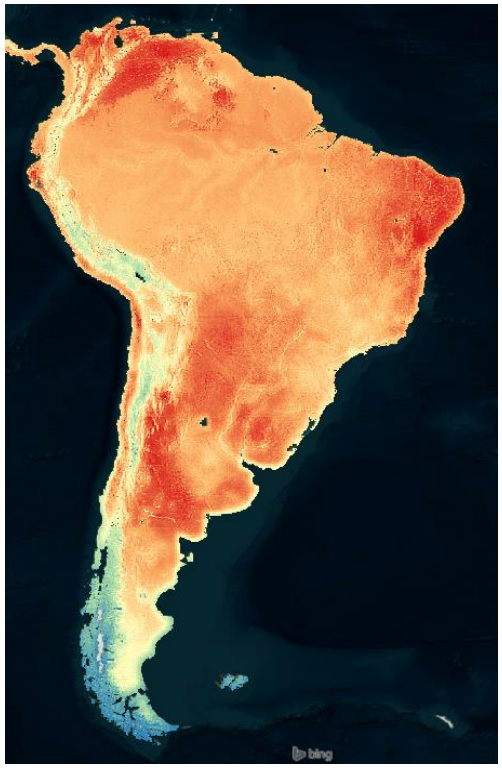


1 km Resolution

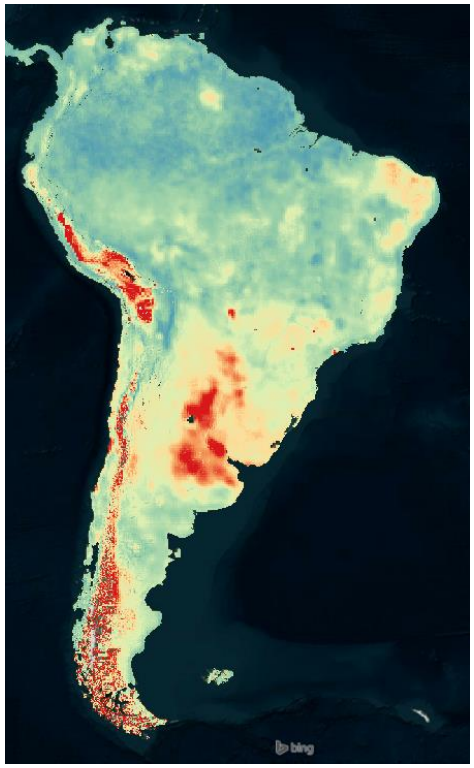
AMSR-E 1km LST Seasonal Climatological Summary Statistics



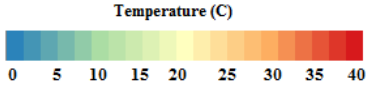
June-July-Aug Day Mean Temperature

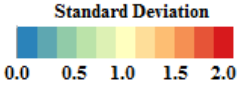


Dec-Jan-Feb Day Max Temperature



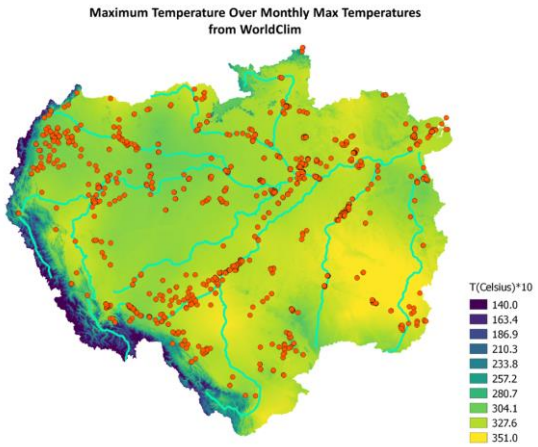
June-July-Aug Day St. Dev. of Temperature

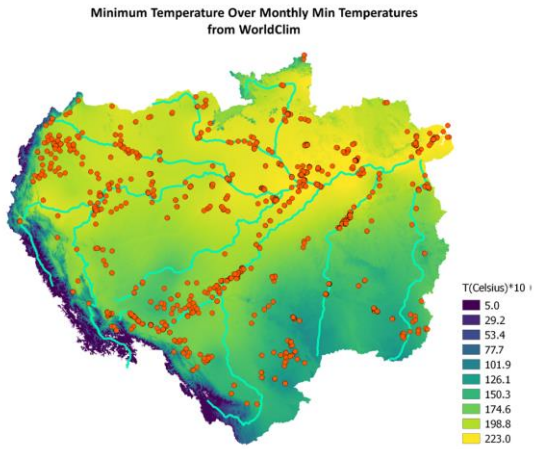




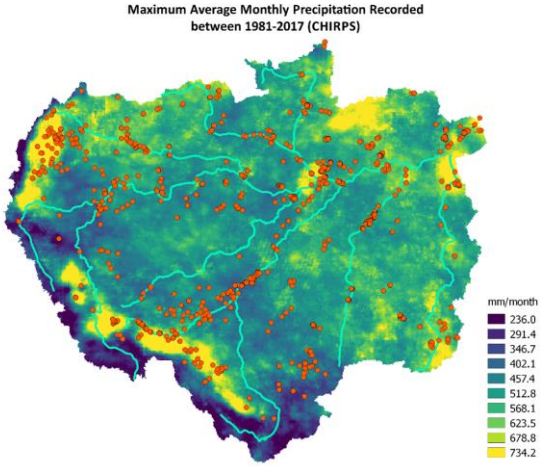
Climatology Analysis over Amazon Tree Diversity Network Sites

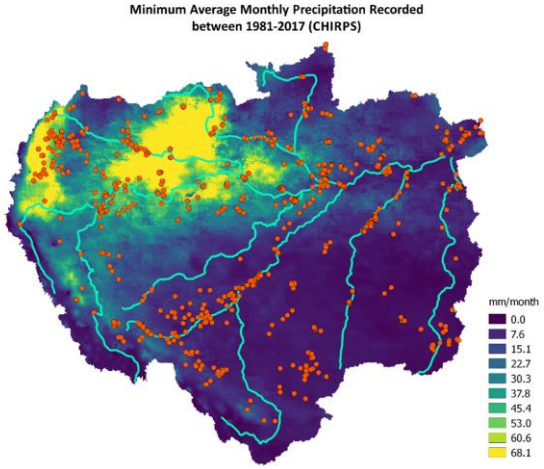
WoldClim Temerature





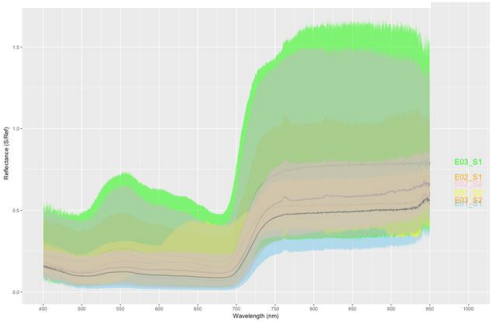
CHIRPS precipitation data.



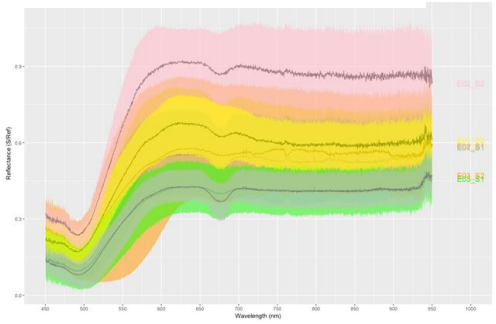


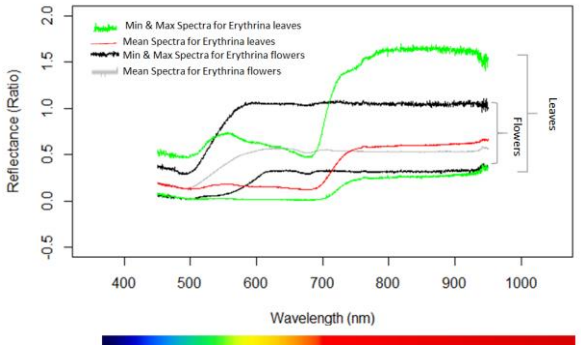
Tracking Flowering Events in the Amazon Rain Forest, A Remote Sensing Approach

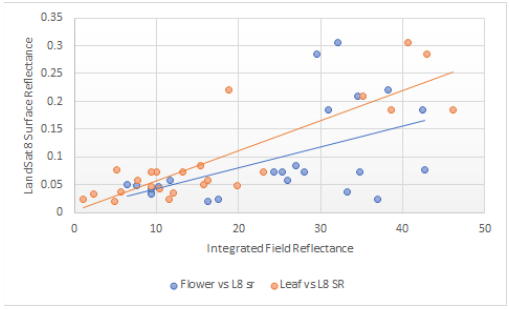
Spectra of the Leaves

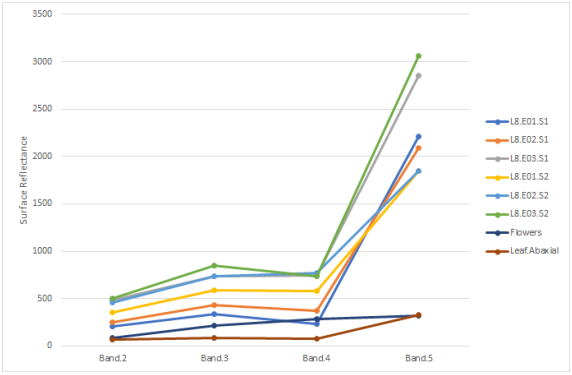


Spectra of the flowers



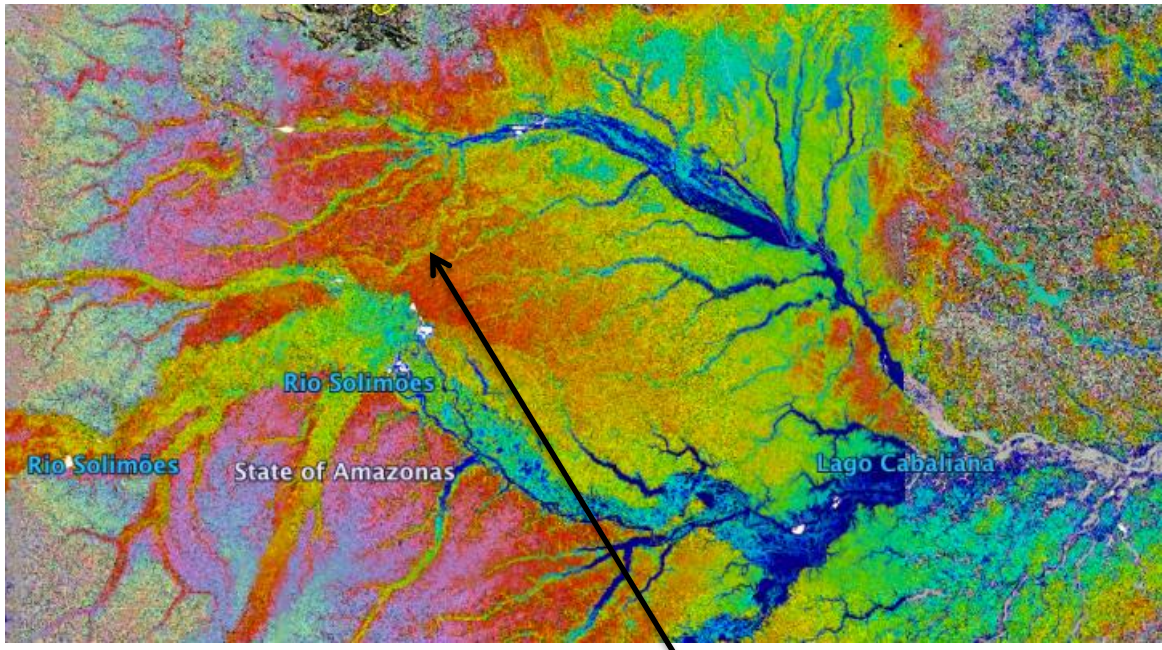


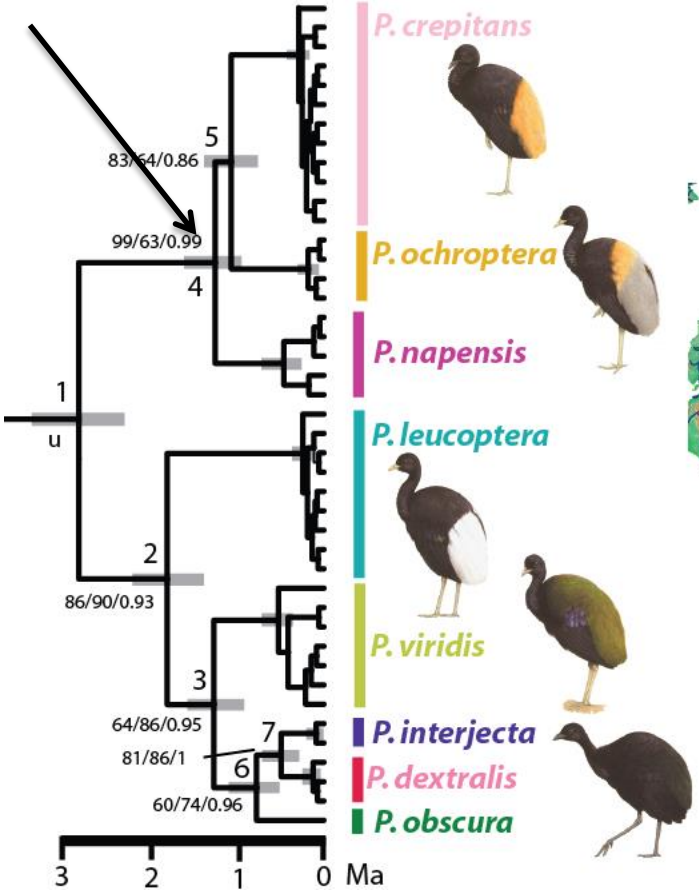


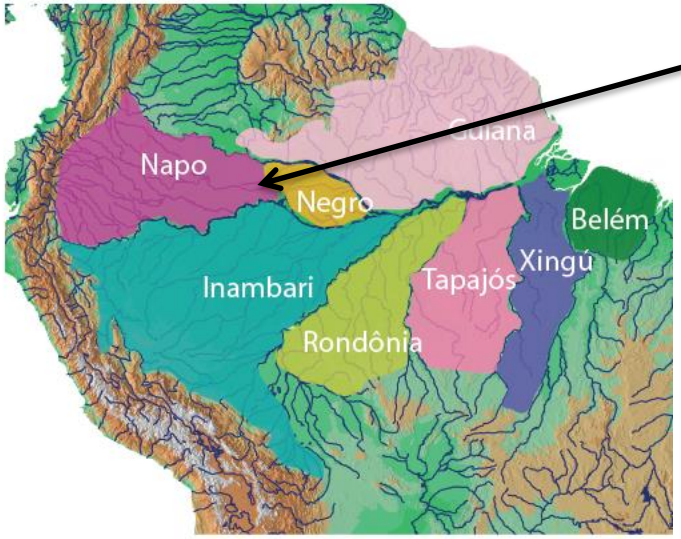


Hypothesized paleoriver postulated by phylogenetic analysis

later verified by remote sensing



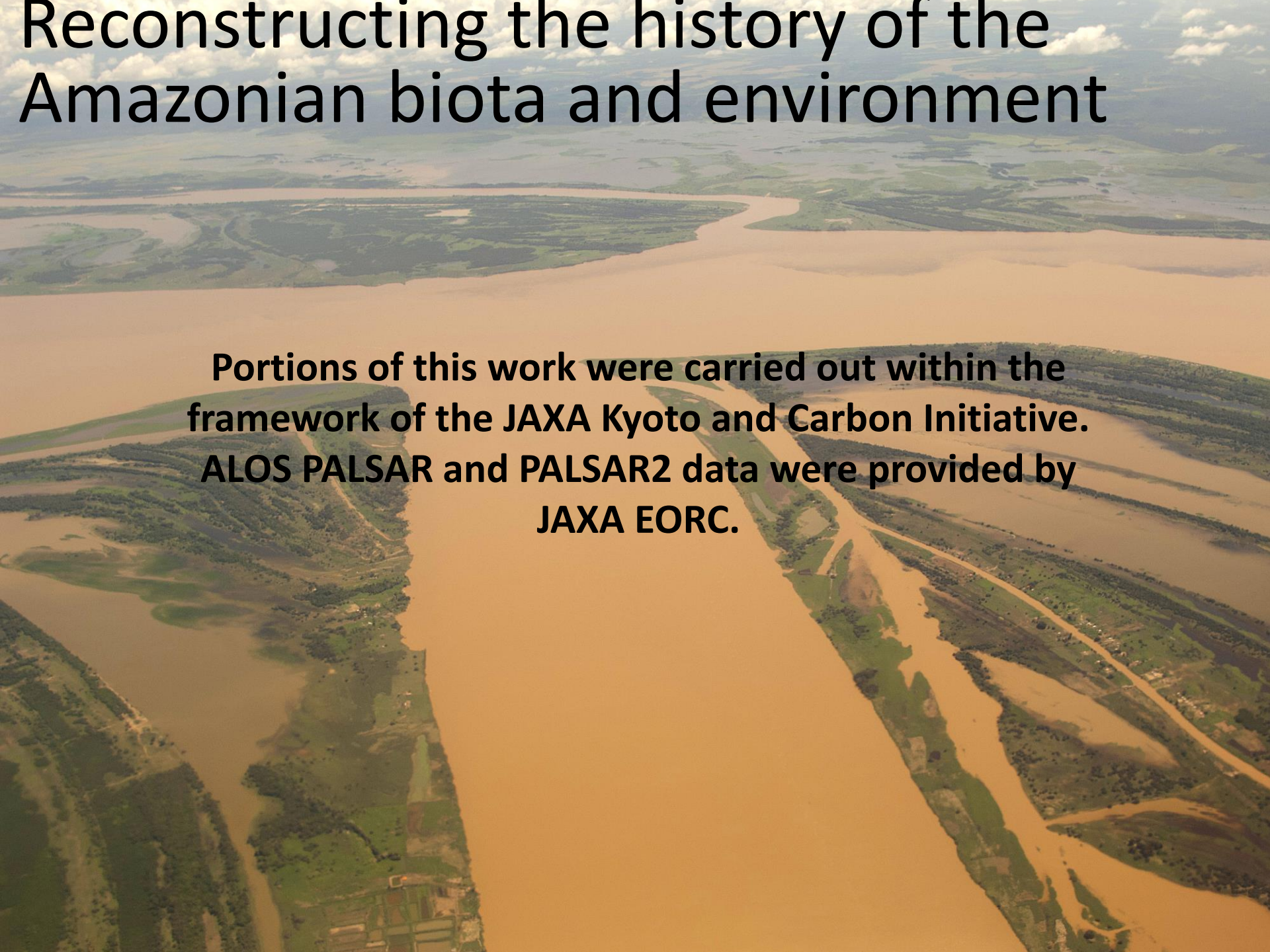




postulated paleoriver vicariance event at ~1.2 myr between *Psophia napensis* and its sister-group (*P. ochoptera* + *P. crepitans*)

Ribas et al. 2012 *Proc. Roy. Soc. B*. 279:681-689

Reconstructing the history of the Amazonian biota and environment



Portions of this work were carried out within the framework of the JAXA Kyoto and Carbon Initiative. ALOS PALSAR and PALSAR2 data were provided by JAXA EORC.